Materials & Methods

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MORE COOPERATION AMONG ENGINEERS AND PRODUCTION MEN
Davidlee V. Ludwig 63

SELECTING STEELS BY HARDENABILITY BANDS
Charles M. Parker 68

PRINTED ELECTRICAL CIRCUITS
Kenneth Rose 73

VERSATILITY OF RESISTANCE WELDING
Joseph W. Kehoe 77

GLASS FIBERS AS ENGINEERING MATERIALS
Kenneth Rose 82

DEEP DRAWN MAGNESIUM PARTS SAVE WEIGHT
R. G. Gillespie 86

INSTALLING A QUALITY CONTROL PROGRAM
Norbert L. Enrick 90

A NEW ZINC-BASE FINISH FOR STEEL PARTS
J. A. Williams 95

SALT BATHS FOR METALS
"MATERIALS & METHODS MANUAL" NO. 24
Edwin Laird Cady 99

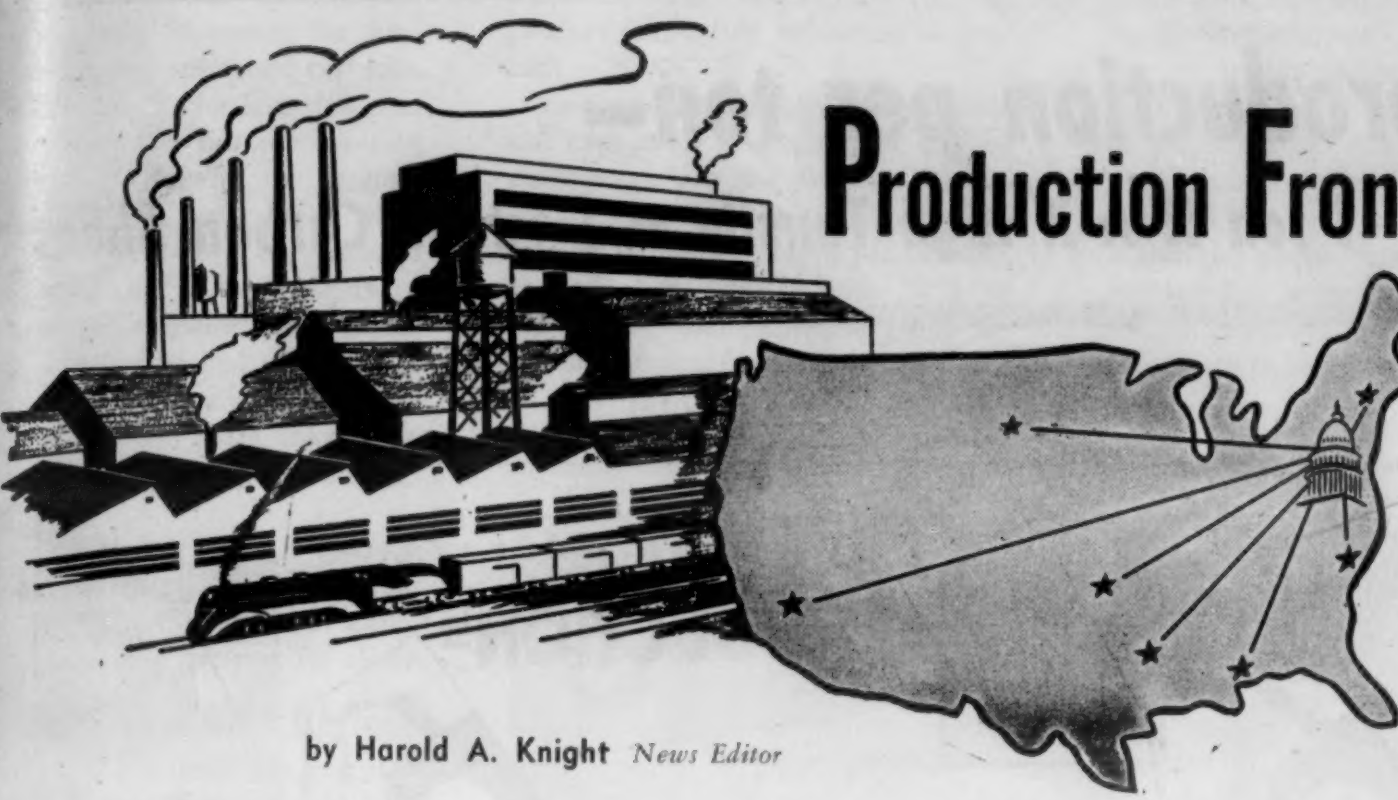
DEPARTMENTS

Production Frontiers 3
The Materials Outlook 8
Editorials 59
Contents Noted 116
Engineering File Facts 119
MATERIALS & METHODS Digest 125
Shop Notes 132
Manufacturers' Literature 134
New Equipment and Materials 139
News of Engineers, Companies, Societies 153
Meetings and Expositions 158
Book Reviews 159
Advertisers and Their Agencies 228
The Last Word 230

NEXT ISSUE: What's Happening With Plastics Prices and Supplies . . . Alloy Wire for Aircraft Cable . . . Magnesium Extrusions . . . Inert Gas-Shielded Arc Welding . . . The Broachability of Materials . . . Isothermal Heat Treatment of Cast Iron Cylinder Liners . . . Protecting Zinc Surfaces

A PLASTICS PRIMER FOR ENGINEERS
MATERIALS & METHODS Manual No. 25

Production Frontiers



by **Harold A. Knight** *News Editor*

Ascertaining the Keynote of Washington Thought

We took our tuning fork to ashington recently and continually pped it on our heel to set it up into ibrations, thereupon placing it to r ear. We were trying to ascertain e keynote in Washington, for ually the key in which the fiddle being played at Washington is the ey that governs the song and dance our economic and social life roughout the country.

When we took our tuning fork to e Capitol a year ago we found that e popular key was that of the theme tty, "The Song is Ended But the elody Lingers On." In other words, e New Deal was in fact "ausge-ngen," but Truman and his advis-s were still rather fiddling away in e same minor key.

The Republican-dominated Con-ess was in session during our re-nt trip and our tuning fork indi-ted a major key was the dominant e. Cut down expenses, plan na-onal defense unceasingly, and spank bor.

One of the prominent senators sug-sted, for instance, that the budget the Army and Navy can be cut uch more severely than meets the e. His argument is that in the next ush button war" there will not be ed for a large standing army or fantry. Rather should a large share of the money be spent for technical development. Again he suggests a severe cut in the number of government employees. Use 1938 as a yard stick in determining the number of employees needed, he suggests.

National preparedness was also very much in the mind of another prominent Washingtonian, who was formerly with Army Ordnance. "We have tempted Providence by our unpreparedness seven times since 1779. Surely by now we have learned our lesson of preparedness. Moreover, right now we do not have the materials and resources such as copper and other fundamental materials to fight another war." From another source we hear that by March the Reconstruction Finance Corp. will have in its reserves scarcely a pound of copper, by contrast with 170,000 tons of zinc.

Then we listened to a man prominent in the labor department. He is apparently fearful that the Republicans will be too severe with labor. He said: "I think there is a reasonable probability of industrial peace over the next several months. We've gone through the era of most destructive disputes." Then he went on to say: "To have a democracy we've got to have delays and inconveniences. Collective bargaining is necessary in a democracy and we mustn't throw away what we have painstakingly built up. Pass a law against the closed shop and you'll have chaos."

Line-Up of the Metals

There has been a decided trend towards nonferrous metals over the past half century, stated Dr. Zay Jeffries, General Electric Co., noted metallurgist and medal winner, who spoke before the New York Chapter, American Society for Metals, in early February. Thus, prior to 1890 production of iron and steel, in ratio to nonferrous metals, was 19 to 1, which changed to 14 to 1 by 1935. During the war the ferrous metals made a slight relative gain, the ratio being 15½ to 1, but this was not representative because the warring nations used what metals they could get hands on and not what were best for the end uses necessarily.

The early 1920's mark the beginning of a "quality" phase in metals, the consumers getting away from mere bulk and tonnage and emphasizing tailor-made metals, of which alloys play prominent roles. This growth of alloys promoted use of nonferrous metals. Metals are being used in combinations as never before —and not necessarily as alloys.

One metal has caused three revolutions in industry during the past half century. Thus, tungsten, in form of high-speed steel, made it possible to

accomplish in five days what formerly demanded six in industrial work. The second revolution was introduction into electric lamp filaments; the third being as tungsten cemented carbides. It may have been the last that was most responsible for our ally winning the Battle of Britain in August-September, 1940, for carbide tools gave the British and us enough speedy production to keep plenty of fighter aircraft in the air. (Radar must not be overlooked.)

Uranium, which we've been "kicking around" for 40 years, may easily cause more industrial revolution than did tungsten.

Dr. Jeffries presented an interesting statistical study of metals and their relative importance from standpoint of quantity produced. He classified the ferroalloys, such as ferromanganese, tungsten, etc., along with pig iron. On this basis the pig iron group leads for highest world production, its peak having been reached in 1942. Copper is second, the peak in 1942. Others, in declining order are: aluminum, 1943 (having nosed out zinc); zinc, 1941; lead, 1939; tin, 1941; magnesium, 1943; nickel, 1943; antimony, 1943; cadmium, 1943; cobalt, 1938.

Note that no world production records were established in 1944. This is because in earlier war years industry was being expanded as to plant and equipment. Thereafter only materials to process through the plants were needed. Note, too, that lead reached its peak in 1939, indicating that lead is past its potential for expanding and may be definitely an ebbing metal.

Had molybdenum not been classified by Dr. Jeffries as a ferroalloy (with pig iron) it would have followed nickel in the above line-up and tungsten would be ahead of cobalt. Manganese would show up favorably, too.

Stainless Sheet—Now and Tomorrow

Fabricators and users of engineering materials should keep closely posted on the materials-producers' operating innovations and future plans, for they provide an intelligent basis for product development and production planning. We recently were taken behind the scenes of the stainless steel sheet industry by the only producer making that material exclusively—Eastern Stainless Steel Corp. of Baltimore—and are pleased to give you our interpretation of what their activities signify for the product-fabricating industries in general.

Eastern, as the result of a substantial expansion over the past two or three years, now has the largest stainless sheet producing capacity in the country (about 2500 tons per month), and supplies industry with 20% of the latter's total stainless sheet requirements and over 25% of its needs for *polished* sheet. They have worked out a system of production which makes the best possible use of batch sheet production methods in both hot mill and cold rolling operations. With all its types, grades and finishes, stainless steel production requires the maximum versatility and flexibility of its manufacturers, and Eastern's setup provides exactly that.

Eastern's experience with the stainless sheet market is not only reflected in the company's methods and processes, but also reveals a pattern of great potential interest to stainless users. Stainless steel sheet consumption is steadily increasing, and at its present rate of growth this material is assuming a dominant position among corrosion resistant sheet metal products.

But the phenomenal expansion in demand has been for *polished* sheet, which designers and fabricators are calling for in unprecedented amounts. To meet this increasing demand Eastern, for one, has expanded its polishing department from an original 3 machines to 23 machines specially designed for rapid, efficient polishing of stainless sheet.

The stainless sheet producers look to a group of four or five equipment industries to take an increasing share of their output in the next few years: dairy equipment; food-processing equipment; textile machinery and

arts; kitchen and cooking equipment; hospital, restaurant and institutional equipment; and, of course, transportation equipment of all kinds. Indeed, the demand for hospital, restaurant and household equipment made of stainless steel is far greater than the existing fabricators of such products can supply.

Therefore, if the producers of stainless steel sheet have one important suggestion to make to the fabricating industries, it is this: There is a substantial and profitable volume of business awaiting new or old shops who will enter or expand the field of fabricating institutional and household products (for example, hospital equipment and milk pails) made of stainless steel sheet.

Steel on Ice

It is quite the thing at ice carnivals these days to have a professional clown act to give a comedy relief to the more serious business of acrobatic and fancy skating. Such an act is a trio, "The Bruises". Their typical stunt is to come charging onto the ice as charwomen, pails and mops swinging. They wear oversize cotton dresses that bulge in all the wrong places. As they brandish mop handles at one another, a hat falls off which is promptly used as a puck in a mock hockey game.

The story is told by J. Robert MacAllister in the January issue of *Steelways*, published by the American Iron & Steel Institute. It is really a story of the steel in skates and we will condense the original. The members of the trio are either long-experienced skaters or skate-sharpeners, or both. They were interviewed by Mr. MacAllister, a metallurgist and son of a veteran heat treater.

"Grinding is a ticklish job," one ventured. "You can ruin a pair of fine skates in a few seconds if you don't grind them accurately. Take off a little too much steel at one time and they're done for. Too deep a cut with the grinding wheel builds up a lot of heat on the surface of the blade. This may draw the temper from the blade and make it so soft it won't hold an edge; or it may cause minute cracks along the edge of the blade itself. Those cracks finally go clear through the metal.

"We were doing our 'Tishy, the Horse' at Cleveland, I being the hind feet, when my right blade snapped. Sid, the fore feet, dragged me all over the place on one foot, not knowing what happened. The audience loved it.

"The idea in making a skate blade is to keep it as light as possible, meaning best quality of steel. I am not a steel man, but heat does something to steel, changes its innards somehow. And the final product is very hard. When you get a blade with a hard edge and a fine, springlike body, you have one you can depend on.

"Take a good pair of figure skates today—they will cost almost $100, for there is much weight-saving and skill in them. The skates are hollow ground, both on the bottom of the blades and between the blade edges and shoe plates, that is, on the sides. Even the shoe plates are streamlined, using thick metal only where major weight is supported. The blades alone cost $20 to $30.

"One of the bugaboos of skating is stripped edges—done by skating over a shoelace, a hairpin or other metal object. Once I skated over a teaspoon and cut it clean in two. Racers are different from figure skates in that they are ground flat across the bottom instead of hollow ground, thus keeping them on top of the ice instead of cutting in. Racers are not much thicker than the width of a 5-cent piece and get their strength from a thin steel tube brazed to the blade.

"Hockey skates have by far the thickest blades and are hollow ground so that the blade has two keen edges for sharp turns, the same as figure skates. They have steel tubes just as racers, but with a shorter and heavier blade to withstand the terrific beating they get. Tubular skates are much too rigid for fancy figures. They have no spring. Also, they make too much noise. The tube on a skate acts like a piano's sounding board. The blade sets up vibrations and the tube amplifies them. The noise wouldn't do for the fancy figure skaters."

Two Kinds of Thinkers

Once a year we clean up our desk—whether it needs it, or not. We ran across an attractive little book that luckily we had not thrown away, called "Your Life in the Machine World," written by Leighton A. Wilkie and distributed by the DoAll Co., Des Plaines, Ill. Not only does it contain homely philosophy, but it sort of hooks up the past in the machine age with the present and gives one a good perspective of things. As "Duffy" of "Tavern" fame would say, "leave" us quote:

"There are two kinds of thinkers: (1) The scientists and craftsmen who are accustomed to reaching a clear-cut solution to problems and can prove that the conclusions are right; (2) the academic and political individuals who have a mental adaptability and willingness to compromise.

"You will nearly always find the most practical leaders are those who have had a background of early practical work. They received their training as 'doers'. They often began working with their hands. But a group of highly educated cannot apply this education with sound judgment because too much of what they know is wrong. Often they develop a sublime egotism and are so presumptuous as to usurp a personal leadership that belongs to the proper processes of democratic law-made government. These are 'Bureaucrats.' They have superior ability to express themselves. Because they are so cocksure, they make their arguments plausible and gain a large following.

"These bureaucrats lack the common sense of a man who has had the hard knocks of growing up in competitive enterprise to teach him sound, practical judgment in the way of life. Beware of the 'planner' because he expects to attain power over men which he could never attain in competitive enterprise. There are many who believe that free enterprise is today being given every opportunity to 'make good.' Many mid-class people, business men and workers have been led to believe that if free enterprise fails to provide full employment we have an alternative in 'planning.'

"This is the most vicious and dangerous complacency in America. Throw out free enterprise and all personal rights would vanish. Creative initiative and enterprise would flounder. Force would be the order. It would be an appalling era of spreading poverty instead of spreading wealth."

The MATERIALS OUTLOOK...

Steps to Improve Soda Ash

In our January issue we stated that production of aluminum would be slowed down a trifle by shortage of soda ash. But this shortage will be only temporary. Thus, the Kaiser interests are building a soda ash production plant in Inyo County, Calif., having secured a 20-year lease from that state for extraction of 500,000 tons of brine per year from Owen's Lake. This amounts to 100,000 tons of soda ash per year.

We're World Steel Suppliers

Again we reiterate—that steel promises to be scarce for very many months, perhaps into 1949. Actually, we are steel makers for the world since the important German and Japanese steel industries are almost completely gone. Though steel, as a commodity, which we export may be only 10 or 15% our total, actually tremendous quantities of steel will enter the finished goods we export, such as locomotives and industrial machinery. Look at steel through the eyes of just one consumer—the railroad car builders. They went through ten years of depression, then five years of war, with good condition freight cars now fewest in modern history. One order alone involves 36,750 freight cars for rehabilitation of France, endorsed by the State Dept. And—scarcity of freight cars slows steel production and hauling of raw materials into steel plants—and outgo of finished steel.

Automobile Steels

It has been a far cry from the strictly utilitarian Model T Ford to the glamour streamlined cars of today. More and more are cars being sold on appearance rather than sterling quality of materials going into mechanisms. In mechanical parts the tendency for automobile makers will be to use the cheaper alloy steels which can be made just as serviceable as the richer alloy steels through improved techniques such as precision heat treatment and shot-peening. Take the latter. During the war some automotive manufacturers could not get the high alloy steels, had to make the best of cheaper steel. They shot-peened and had the best ever. As to the glamour items, expensive materials will not be scrimped. The tendency, for instance, is to be profligate with nickel, with heavier plating on bumpers, grilles and hardware.

Motor Weight Reduced Again

One important step was taken recently by an electric motor manufacturer who redesigned his motor so that equal horsepower occupied smaller space. Look for another 10% reduction in size and weight in motors and generators because of a new iron-cobalt alloy, tough enough to withstand intense vibration. It is sponsored by Westinghouse.

Future Tin Plate Corrosion-Proof

Look for an improved tinplate soon. The new process produces an oxide film to prevent rusting from atmosphere and black staining from some food products. The film is invisible, but a simple test has been devised to tell easily whether or not any doubtful plate has been treated. It is called the "Protectatin" process.

Expanding Stainless Steel

Be sure that you get your share of the expanding production of stainless steel, which will attain a new all-time record of 650,000 ingot tons in 1947. You engineers are appreciating more and more its creep strength, ability to remain strong at high temperatures, uniform ductility and high strength-to-weight ratio. Quantities consumed line up as follows: Makers of automotive equipment, kitchen accessories, food processing equipment, transportation, mechanical refrigerators, agricultural, brewery and petroleum refinery equipment.

Flat Strips from Round Wire

It may seem awkward, to get flat strips, to start out with round wire, then roll it flat, but that is just what one German maker of watch springs wire did, and it may be adopted here. Chromium-nickel rolls were used for flattening what became mainsprings. After rolling, the round edges of the strips are flattened on grinding wheels. Mainsprings as thin as 0.05 mm. and 0.5 cm. wide are so made.

Titanium "Going to Town"

Titanium is a rare metal as to plentifulness in the refined or oxide stage, though the ninth most abundant chemical element in the world. Until 1900 no pure titanium had ever been made except in laboratory experiments. Until recently no satisfactory method of commercial production had been devised. Now the Bureau of Mines has developed a process that promises to make it plentiful, a pilot plant producing merely 100 lb. a week, which, with improved engineering, will mean truly quantity production in the future. The Bureau's process consists of reducing titanium tetrachloride with pure molten magnesium in the presence of helium gas under pressure, thus preventing oxidation during the process. Titanium makes paints and paper opaque, it "stabilizes" stainless steel, and will have myriads of other uses, come quantity production. It has a fine future as a structural and corrosion-resistant material.

Pig Iron Imports Help

The pig iron bottleneck in the East will be at least partially broken by an import movement in pig iron from Great Britain, the first in 20 years. At least 1000 tons has arrived at Boston, and more is said to be on the way. Britain will deny herself essential materials to help her own balance of trade. Iron castings in the East will therefore be a bit more plentiful. At other times of scarcity here much pig iron has been imported from Holland, but damage to the Holland blast furnaces makes uncertain when Dutch iron will again come here.

AN EDITORIAL

Fewer Dollars and More Sense

We've just had a warm chat with an old friend to whom we frequently flee for comfort or counsel when life begins to look a bit mixed up from where we sit. This time we were concerned about the upward trend in costs and prices, especially in industry, and about the possible disaster that could befall our system should this trend continue unabated.

Since he is an old-timer, experienced in all phases of operating a small manufacturing plant and infinitely wiser than we, we knew he'd have some ideas on the subject that not only would set our own restless mind at peace but might also prove helpful to our readers.

"Yes," he started, "we do have a problem, and I for one certainly don't know the answer. But one thing is clear: What this country needs is fewer dollars and more sense! Fewer dollars in circulation, fewer dollars to the government, fewer dollars across the counter for products—yes even fewer dollars for a day's work or a year's profit. It's like fitting a pair of pants; if in trying to match the lengths of the legs you keep making one and then the other a bit longer, pretty soon you'll have a completely useless pair of pants, instead of a well-fitting, serviceable garment.

"So instead of thinking in terms of more dollars for everything, we've got to begin talking of *fewer* dollars, and then doing something about it. Industry needs a sense of values just as does the individual. A man whose ambition for money or power leads to the ruin of his family life is considered a fool by intelligent people; industry is a family, too, and too much ambition can destroy the family and bring misery to all its members in exactly the same way.

"It makes sense, too, for men to use their brains to reduce costs rather than to waste them figuring how to increase prices. If you would carry a torch in your field for the common man, don't worry too much about social justice and this or that ideology; just go out among your technical experts and production wizards and teach them to cooperate with each other in making more things, less expensively. And in the end most people will be happier and actually more prosperous that way. But," he concluded, "the men who plan things and make them in industry have got to think first in terms of lower costs and then they've got to work together to get them!"

This opportunity to make sense with fewer dollars is shared by all of us—you who are so heavily concerned with materials and their processing as key factors in production costs, we as editors trying to feed you information that will help. In various ways (*e.g.* Mr. D. V. Ludwig's hard hitting article on cooperation in this issue, our series on the economics of engineering materials, and the "costs" theme of our 1947 Achievement Award) we have taken up the challenge of lower costs.

And we hope fewer dollars makes more sense to you, too!

FRED P. PETERS

EDITORIAL COMMENT

The Proper Selection of Materials

More and more people are coming to the realization that the proper selection of materials is one of the most important problems facing industry today. Tradition, past loyalties and blind selection of a material—because it sounds glamorous or looks good—must all be abandoned and each material picked on the basis of how close it comes to the ideal material for the intended application. There is no need for such improper choices of material as those which have often plagued plastics and stainless steels, just as there is no justification for failing to use a new material just because some older material has been used exclusively for many years.

It would be wonderful if we could come up with one or two materials that would meet the requirements for all applications. Unfortunately—or perhaps fortunately—the trend is definitely in the opposite direction. Every day we learn of new materials designed to meet the needs of specialized applications. Therefore, wise managements are spending more time and money on materials selection, knowing that the costs incurred will be recovered in higher quality and reduced operating expenses.

—T.C.D.

To Change or Not to Change

A new executive of a very old business went over the company's old records to its origin, primarily to study prosperity waves and depressions. The story is told in the house organ of Rogers & Slade, management consultants, who tell it as follows:

"The records showed that for a period of years the business would sail along, making good money and chalking up progress; then the management would tire of so steady a course and so simple a business formula. Products would be changed, the old selling plan would be 'modernized' and the advertising given a glamor treatment. Whereupon the business would enter on a period of small profits and little progress."

And, after studying these records, the new executive went to the president and said: "This business is off the track again."

All of which suggests that to many a company sometimes comes that most vital of all decisions—whether to alter the product, take on a different line of manufacture and violently alter the current merchandising plan.

If Studebaker had continued merely their manufacture of wagons and never gone into automobile manufacture, they would not be where they are today. Manufacturers of kerosene lamps would probably have stagnated when electric lamps came into being if they had not switched to other products.

There are still manufacturers of horseshoes who are apparently doing well. But they are doubtless the few survivors from a large group of successful manufacturers of a bygone day. These survivors were undoubtedly the ones most strongly entrenched in the business, who had the best machines, the most intelligent know-how and managerial acumen.

But one must not take the lessons of the house organ piece too seriously. We venture to say that this case history was the exception rather than the rule.

The best plan, we believe, is to be ever on the alert as to what new products, at least somewhat related to original products as to types of machines needed, can be taken on. But this is a time for most exhaustive research, both as to the quality of the proposed product compared with competitors', to marketing possibilities and consumer acceptance. If these researches indicate the green light—go ahead with all energy and resource.

For after all, in this unstable world of ours nothing is more unchanging than change.

—H.A.K.

Workers Are Human

Too often in the past the problem of increasing productivity has been considered strictly a technical one, in which such things as materials selection, product and process design, and materials handling are the all-important factors. However, recent experience has shown that the human factor is also important and cannot be ignored. No matter how great the technological advances might be, it still rests with individual workers to transfer these into actual increased productivity. And without the workers' wholehearted cooperation, increased production above a certain point is impossible.

One of the inevitable consequences of mass production techniques has been high specialization of the worker and his loss of satisfaction that comes from looking at a finished product which he alone has produced. This loss, which even an increase in pay cannot completely offset, is probably one of the principal causes for declining labor productivity.

Harry Brearley in his illuminating book, "Talks about Steelmaking," puts the matter this way: "The moving-platform notions of industry link up with the idea that increased production of anything which can be sold at a profit is good; and that the lives of men may be subjected, as hands, to serve mechanisms however impersonal and uninteresting their jobs might be. These are evil ideas; and on escaping from the din of ignorant assertion which has hammered them into people's minds, they are seen to be abuses of what is most valuable in life—self-respecting manhood. If there is less and less reason in a man's job, it is folly to expect him to grow reasonable; he must grow either frantic or daft."

So, it is becoming more and more evident that in dealing with production processes which involve human beings, the technical man cannot merely exercise his engineering techniques. He must also strive somehow to adapt his procedures to win the cooperation of workers.

—H.R.C.

Materials & Methods
THE METALWORKING INDUSTRIES ENGINEERING MAGAZINE
MARCH 1947

Rising living costs hurt "white collar" workers most.

We Need More Cooperation Among Engineers and Production Men

by **DAVIDLEE V. LUDWIG,** *Consulting Materials Engineer*

IT IS A STRANGE, but true, condition that the spiraling cost of living hurts engineers and other salaried, "white collar" workers, most, yet they are the ones who often are in the best position to control the underlying reasons for rising prices.

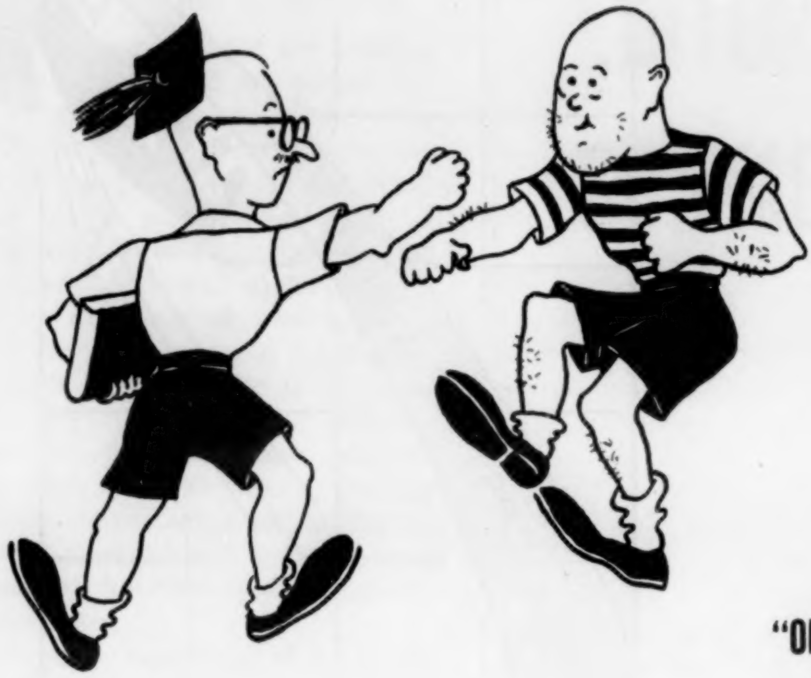
Most technical men, most foremen, even most management officials may deny this statement. Increasing hourly wage rates being exacted by stronger and stronger labor unions, increasing raw materials costs (merely another evidence of more expensive labor), slow-down production tactics of unionized shops, and any of a dozen other answers will be advanced, in preference to consideration of the lack of cooperation among technical and production men.

With a little thought, any engineer, chemist, physicist, metallurgist or control foreman will begin to see there may be justification in this approach to the problem. The growing tendency towards the unionization of foremen and of certain classifications of office and technical help is believed to be in protest to the known inequities which have arisen as a partial result of the failure of salaries to match the fast growth of hourly wages.

But, the economic factor, while of prime importance to the individual, is comparatively minor in comparison to that old green eyed monster, jealousy.

Also, war expansion, resulting in too-rapid promotion of too many unqualified individuals, placed the

Not all high production costs are due to labor's demands. Often a lack of understanding between technical groups proves costly in more ways than one.



Often grown men act like children in performing their daily jobs.

greatest emphasis upon the emotional capacities of all management and technical personnel. No technical man who worked through the war, in any industry, can fail to understand this problem—a problem which was so slightly attended to, and which in effect sabotaged many phases of our industrial effort.

The experiences of consulting engineers serve to point out the lack of intelligent coordination of effort in almost every instance of service. *It is nearly 100% true that the information sought for and paid for outside a company's own group could be gained from the existing members of the organization if the many barriers of personal jealousy and intellectual incapacity were removed.*

While serving on the War Production Board, the author was taken into the confidence of one of the "specialists" in managerial problems who had been a somewhat successful consultant in that complex field of industrial relations before joining the WPB. It is not possible to quote verbatim, but the gist of his boast can be summed up as follows:

"Though I have no formal background, either educational or practical, in any specific industrial method or professional field, my work has always been in the field of management problems. As a consultant I have always made it a point to leave the time clause in my contracts open, collecting only per diem "expenses" until my report is submitted. By drifting from department to department, giving the impression I know everything by knowing enough to keep my mouth shut, eventually I hear enough complaints about a given problem, and enough suggestions as to the proper solution, for me to give a good guess as to the difficulty. Usually my reports are the opinions of the foremen and technicians, unchanged even as to phraseology. It's a good racket, particularly when you don't know anything."

Certainly not all consultants are as unqualified as that man was. Nevertheless, it is usually true that the outsider does little more than serve as a sounding board for the opinions of men who cannot or will not talk frankly to one another.

"Old-timers" Oppose Change

All of this is undoubtedly aggravated by the normal attitude of "old-timers" who, both in technical and practical classes, seem opposed to change by nature. There is a simple explanation for the resistance to change, which lies in the fear that lack of knowledge of new methods or materials will cause loss of prestige, position or income. Furthermore, there is the inevitable resentment which is felt and shown by older men when younger men attempt to demonstrate new ideas which affect their established modus operandi.

A classic demonstration of both the lack of basic knowledge and the absence of proper attitude occurred when the Chief Engineer of a war plant manufacturing exceedingly critical aircraft ordnance instruments made this remark: "I don't give a damn how poor the material is, as long as the finished part works!" He voiced that wisdom when being shown some exceedingly poor castings, which had been rejected for more than ten reasons of physical and chemical imperfection, but which he had judged suitable in overruling the rejection orders.

This engineer did not consider how long the part would "work," if at all. Mere compliance with initial dimensional tolerances is no indication of the ability of highly oxidized cast metal or an improper base composition to remain stable and conform to the original close tolerances while in service.

However, this attitude on the part of this man and his associates resulted in the production of instruments of such low quality that thousands of lives were lost in the effort to use them.

Every practicing engineer and metallurgist knows of instances where loss of production time and material could have been saved had a more friendly spirit existed among the men. Why is it that grown men can act like children while nominally doing their work? Some seem to scorn other classes of technical men. In their eyes the Physicist, Chemist, Metallurgist or Mathematician is a less qualified man who, for reason of insufficient gray-matter, was unable to cope with the complexities of the formal engineering curricula.

Nothing can be farther from the truth. A good

physicist is generally a fundamental engineer, to begin with. A good materials engineer should know much more about design data than most design men seem to know about materials. It is frequently the metallurgist who must correct the mistake made by the engineer, or it is the chemist, or the physicist, or even, the wild eyed dreamer, the mathematical analyst!

Such engineers are not alone in their ivory towers. Metallurgists and production men are also guilty of scorning engineers or each other for a variety of groundless reasons.

A particularly silly incident may serve to illustrate how directly a production schedule may be wrecked by lack of cooperation among the technical people and production foremen. This example occurred in the same instrument plant which was plagued with the previously mentioned chief engineer.

The instrument was a British gadget, one of the most successful inventions to come out of Britain in the war. This made it practically impossible to obtain production and tooling advice from British manufacturers, even if American firms had desired it. As a result, when unexpected difficulties were encountered, they had to be solved without assistance from abroad.

One part which caused many headaches consisted of nothing more complicated than a little flat plate of 24S-T aluminum, which measured approximately 5 by 6 in. and was supposed to be 0.125 in. thick. There were a few holes drilled through it, for it was a mounting plate, but the tricky specification, and a necessary requirement, lay in the demand for absolute flatness and parallelism to within 0.0003 in.

For some reason, the production foreman, in the flycutting department, began producing 90% scrap and continued producing scrap in spite of all the erudite advice from the engineers, the tool designers and other production foremen. The man simply could not make the plate smooth, flat and parallel.

Obviously, he said, the metal is at fault. It is the wrong composition. It hasn't been properly heat treated. It's just no good!

To remove approximately 0.02 in. of excess metal, he was proceeding by cutting approximately 0.0005 in. at each pass of the cutter, then reversing the part and shaving the alternate side. By actual count, he was reversing the part up to 50 times, before it was considered a total loss.

The material being suspect, the metallurgists were pounced upon. All tests and reports from vendors, all control examinations indicated the material was completely satisfactory. So a consulting materials engineer was hired.

He reviewed the metals and production reports, then went to watch production operations. After watching a few minutes, he asked the production foreman, "Did you ever hear of the 'air-bearing' effect?" The foreman didn't know for sure whether to say yes or no. "*That's* your difficulty. You're trying to place two smooth, flat pieces of metal together, without providing a way for the air and oil to get out. No matter how tightly you clamp the part in your jig, the way it's designed, you can't get the air from beneath the part."

The Obvious Overlooked

The jig was a simple, side clamping affair of steel. The plate on which the work was supposed to lie flat, was a superfinished plate of hardened steel. No provision had been made to exhaust the air bubbles which would be trapped when the aluminum plate was slid, dropped or laid on that surface. No amount of pressure would rid the contact faces of the air bubbles. As the bubbles would be trapped in varying places each time the plate was removed and replaced, no uniformity of result could be predicted. Good, true mounting plates were merely inevitable accidents, and the minimum result.

As might be expected, the foreman became incensed at the suggestion that the solution was so simple. He refused to take the step of scribing a grid of relief lines in the face of the jig, and went merrily on blaming the material, making scrap, until the plant was taken over by the Government in order to stop such practices. Put such an incident into a peacetime industrial setting, away from the planned waste of cost-plus war plants, and picture the effect on consumer goods prices. The result would show up in your pocket, Mr. Engineer, or Mr. Foreman. In this instance, quite obviously, the foreman was initially incompetent; the various technicians, unobservant; the management, ineffective. When an answer was suggested, it was not even tried!

In another instance, the design engineers in a certain aircraft plant failed to seek the advice of practical foundry metallurgists, when they decided on certain "minor" alterations in the plans for a plane. The prototype had been accepted by the Navy. But between experimental models and production lay the many bottlenecks of impossible supply situations.

As each bottleneck had been encountered, substitutions had been dreamed up. Most were accepted by the Navy and company engineers without formal flight testing, for few of them affected the structural strength of the ships, and none seemed to hold a vital job. Imagine the consternation when the production planes began to burst into flame, while being warmed up for test. A number of ships were totally destroyed on the ground without ever getting into the air. Several actually flew, but exploded on landing. Was it sabotage? Or what?

It was "or what." One of the insignificant alterations had been the substitution of cast 356-T6 aluminum alloy pipes for the flexible metal tubes originally called for to serve as fuel lines. These lines were 2½ in. and 3 in. dia. and held a lot of high octane gasoline. To pass the lines between the internal braces in the wings and nacelles, it was necessary to cast the pipes in rather short lengths and bolt the sections together. Further, the lengths had to perform some fancy curving to get from here to there.

Oh, the pipes were *strong* enough. They didn't burst or leak under the low fluid pressures of gasoline. Theoretically, so the text books indicated, the cast pipe lines were stronger and safer than the flexible metal hoses. They were less apt to leak, so they thought!

But the design engineers overlooked an important detail. The flexible metal hoses were used not only

Production men are prone to shy away from "impractical dreamers" of the technical staff.

because they could be readily bent to conform with space limitations within the wings and nacelles, but also because they could wiggle and shimmy indefinitely without undue damage. Don't be misled by statements about the "smoothness" of aircraft engines. When they are being started and warmed up, they vibrate terrifically.

Now what materials engineer or metallurgist, in his right mind, would have permitted the application of a cast metal for such a purpose? Particularly a material whose deformation tolerance was in the range of 2 to 5% prior to rupture? The text books relied upon by the designers had not had occasion to mention the wiggle of gasoline lines to aircraft power plants. The designers had not seen the problem with sufficient clarity, and had not sought advice, so a few lives were lost and a lot of planes didn't fly. In an airplane, no substitution is a minor one.

Unheeded Advice Costly

In the case of another piece of aircraft equipment, which the engineers had designed around an unnecessarily heavy steel gyroscope rotor, refusal of the engineers and production men to heed the advice of control metallurgists and heat treaters cost the government untold millions of dollars. The difficulty seemed to lay in the method of balancing the rotors in the assembly department. At least, that was where the whole blame was going. Assembly losses of the vital rotors ran as high as 80% per lot, and were rarely under 40%.

The rotors weighed approximately 8 lb. when finished. As raw forgings they weighed about 16 lb. The forgings were procured in the normalized condition. The parts were sent all the way through production without a subsequent annealing operation. The removal of 50% of the initial mass was done without once placing the parts in a stress-relieving furnace.

Furthermore, the design engineers, fearing the rotational speed, 8,000 rpm., would induce excessive strains in the part, had specified a high strength nickel tool steel as the material. This metal was difficult to machine, even when fully annealed. It was subject to considerable work hardening, especially when dull rough cutters were used. But, as the designers could have learned by consulting any of their brethren familiar with materials, in the fully annealed condition the alloy chosen was essentially no stronger than a free machining low carbon steel would have been. Nearly all steels, of good quality, run fairly close when annealed to the same hardness—the fact that hardness figures can be used as approximations of ultimate strength is proof of this.

When the metallurgist suggested the substitution of a cheaper base material, with much better machine characteristics, the design engineers and management should have jumped to try the solution. Furthermore, when the very proper suggestion was made to fully re-anneal the forgings after all rough machining operations had been performed, prior to the final close tolerance grinding steps, the suggestion should have been recognized as correct. The firm had a fully equipped, large heat treating department, decidedly over-equipped and under-worked.

But the engineers, as well as the production foremen, chose to believe the balancing operations were not being correctly performed. The ultimate cost of these errors will some day cause a national scandal, in so far as this particular plant is concerned. As the general picture of industry is affected, today, though errors as glaringly unnecessary as the above would never long be tolerated, similar attitudes can and do add immeasurably to the overall cost of production of consumer goods.

Not all errors encountered by consultants stem from lack of cooperation. Sometimes just plain ordin-

ary dumbness is the cause. Many times, when unsuspected ignorance is back of a situation, time cannot solve the problem. Frequently the employee responsible for the production condition is totally unaware he is at fault, and is completely free from suspicion.

It is really most important that the educated men in industry begin to grow up a little. All in all there is too much clannishness—too much holdover of the childish affinity for exclusive clubs and fraternities. In one major firm, the over-emphasis on the importance of where a man graduated from, rather than what he knew, as implemented by improperly trained personnel directors, became so serious the firm lost its preeminent standing in its field. When the discovery was finally made by top management, that their new engineers were invariably Phi Betas from a few very selected schools, they were on their way to recovering their business. These children among men became so snobbish it was nearly impossible for the firm to hire good men from schools of lesser standing, and retain them.

But probably the weakest single link in the production system today, and the one of whose strengthening would produce the most immediate effect, is the lack of the spirit of intelligent cooperation between the practical foremen, the technical production men, the engineers and the metallurgists in industry. Most "production" men shy away from close association with the "impractical dreamers" who insist conditions can be bettered.

This has been characteristic of the course of industrial evolution to an extent totally unrealized even by the men most affected by it. "Practical" engineers resist the adoption of new materials, or the introduction of new theories. Designers are still going by materials control safety factors which were required in the first world war. Prompt, correct assimilation of new information should be a must among qualified men. And where the limits of time and space naturally preclude the overall comprehension of all pertinent data in the mind of a single person, people with the information, inside or outside the organization, should be liberally consulted.

Cooperation is Attainable

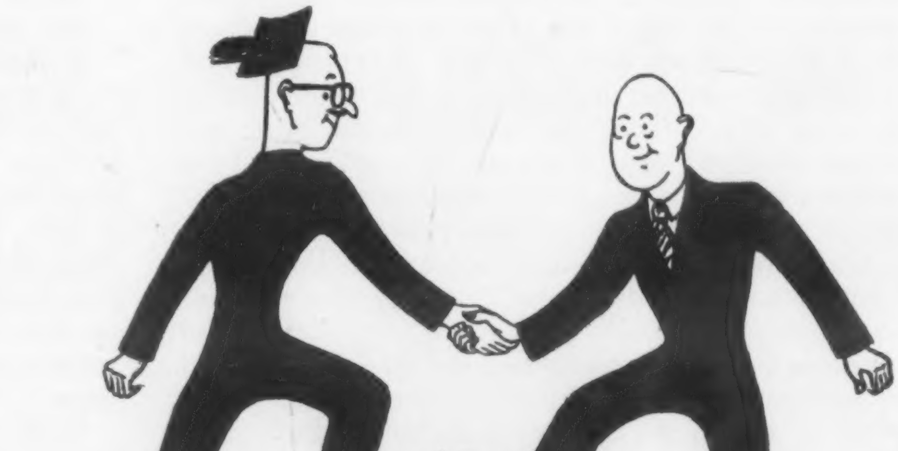
Only those who know they do not know can learn.

But the moral to all this is close to every man's heart and pocketbook. The lack of cooperation among engineers, foremen and control specialists, as well as between research men and designers, is a correctable defect which in itself can go farther towards the improvement of production efficiency than perhaps any other single factor.

This is true, not only because of the improved efficiency which would directly result, but because of the indirect benefit which would inevitably evolve from the producing men themselves. The morale of the men working for a frustrated foreman directly controls their efficiency. If they feel the foreman knows his business and means business, they will work more readily for him. If they know he is sensitive about his limitations, they will take advantage of his weakness—all to the detriment of the firm—with a result in higher prices—and you, the white collar man—the smart technical man, as well as the "practical" foreman, pay through the nose.

We've got a big job to do. Probably the biggest job which has ever confronted the educated, technical minds of a nation. Not only must we devise ways and means of saving the good things from our present technological society, but we must lay the new groundwork for an entirely new civilization. The country which first succeeds in controlling the Atom for productive purposes will be the one to rule the world, or to eliminate the need for division among the peoples of the world.

The best way to insure the future of the study of the Atom is for American industry to begin hitting on all cylinders—a thing it has never done before. It will do no one any good to say, "let George do it"—labor is wrong—management is wrong—we are all wrong until we stop beefing and start working. It seems most logical to suggest that we, the technical people, the so-called bright boys, be the first to clean house and start working together. After all, it's our money we're wasting—and our lives.



We are all wrong until we stop beefing and start working together.

Selecting Steels by Hardenability Bands

by **CHARLES M. PARKER**, *Secretary, General Technical Committee, American Iron & Steel Institute*

INTEGRAL CALCULUS IS IMPORTANT to mathematicians because it is a convenient method of summing up an infinitely large number of infinitely small quantities and presenting the solution of a properly stated problem in simple finite terms. In like manner, hardenability bands are important to metallurgists and design engineers because they sum up many factors relative to steel, each difficult if not impossible of precise evaluation individually, and present a simple, concise answer to many fabricating and heat treatment problems.

The chemical composition method of specifying steels, which has been so long in use, has certain fundamental weaknesses. Grain size, method of deoxidation, alloy balance and other factors also have a decided influence on the behavior of steels during fabrication and heat treatment. Not least of those unnamed factors is the presence of "incidental" or so-called "residual" alloying elements, the effects of which are largely reflected in fabricating and heat treating operations. In light of present knowledge, none of these factors are possible of adequate interpretation, singly or in combinations, in the chemical composition method of specification.

With the development of automatic heat treatment lines the demand arose for steels having closer chemical ranges than ever before. As a matter of fact, the ranges desired were closer than could be manufactured economically and sometimes closer than were really necessary to do an intended job. Added to that, many consumers required certain balances, specifying that when carbon was to the high side of the range, manganese should be to the low side or that carbon plus manganese should not exceed a certain maximum. Such specifications were met only at exorbitant cost to the steel producer and economic loss to the country at large. Even then, the results desired were not wholly achieved because the specification method did not embrace the other factors which affect the fundamentals of fabricating and heat treatment processes.

Ordinary chemical composition tells us little about steel because it does not tell us how the elements are arranged physically. Samples properly taken from the same bar, one annealed and the other heat-treated to high strength, will exhibit the same chemical composition within the limits of analytical error. The differences in the physical structure of the steel, which are marked, can be observed under the microscope or detected by a hardness test, or a tensile test. For fully heat-treated steels between 200 and 400 BHN, the hardness will portray the tensile properties to a high degree of precision.

Because the microstructure of steel and the attendant hardness value correlate well with service performance, a means was sought to utilize hardness and the concomitant structure, as a means of predicting the hardening properties of steel prior to actual use, and as a production control test for checking heat treated parts.

The first attempt to do that was the fracture test which was early followed by the simple hardness traverse as depicted in the well-known U-curves, and more recently by a wide variety of geometric shapes heat treated to a variety of conditions. Because all of these tests have limited application, a more comprehensive test was sought, and found in the standard end-quench test developed by Jominy and Boegehold[1].

This test is now recognized as the standard for constructional alloy steels by A.S.T.M., S.A.E., and A.I.S.I. The following information can be obtained from this test: (1) Maximum hardness and maximum strength at a cooling rate approximating 600 F per sec., which is the fastest quenching obtainable in most heat treating shops; (2) depth of hardness; (3) mass effect; (4) probable micro-structure of the steel under known conditions of heat treatment; and (5) ordinary mechanical properties.

For each one of these statements there is simple supporting evidence in the literature. A prominent metallurgist in the automotive industry has summed up the situation as follows:

> "To us, the conclusion seems quite obvious that a test which gives one the summation of all the things having to do with hardenability, is far superior to composition specifications which, at best, are incomplete due to checking latitude and undetermined factors."

Through the joint efforts of the Society of Automotive Engineers and the American Iron & Steel Institute, hardenability specifications known as hardenability bands were first published in tentative form in June, 1944, for the steels now known as "H-steels." These bands enable the user to specify minimum and maximum limits of hardenability for a given type of steel which will give him better control of hardness variations from lot to lot and thereby minimize retreats.

Steels manufactured to hardenability bands are within much closer limits, as measured by performance in fabrication and heat treatment, than steels manufactured to chemical limits only. The occasional peculiar heat which falls within chemical specifications but which does not anneal, machine or heat treat satisfactorily will be largely eliminated.

In order to maintain those close limits and at the

Faults inherent in specifying steels according to chemical composition led to the development of a method of selection on the basis of hardenability.

same time permit the steel manufacturer to utilize a high percentage of his product, it was necessary to widen the conventional chemical ranges and limits to permit adjustments in melting practice and to take full advantage of the probability of one or more elements being high or low.

In order more clearly to appreciate the closer limits of heat-treatability of "H" steels, let us examine the conditions surrounding a popular standard steel. The chemical composition limits for 8620 are as follows:

Carbon	0.18/0.23%
Manganese	0.70/0.90%
Nickel	0.40/0.70%
Chromium	0.40/0.60%
Molybdenum	0.15/0.25%

The limits of hardenability normally encountered from that composition are shown by the dotted lines in Fig. 1. It is apparent that those limits are wide enough to be troublesome in many shops. In the same diagram, the solid lines show the hardenability band limits for 8620H steel.

It is apparent that the range of hardenability obtainable by specifying the 8620H band is only 80% of that normally encountered when 8620 is ordered. In other words, the "H" method of specifying steel makes possible in this instance about 20% greater control than does the chemical method (Figs. 2 to 5 show other typical alloy grades); the average for all published bands is 26%, but individual cases run as high as 41%. To make such control possible on the part of the steelmaker, the chemical limits for the "H" specification have been widened to read as follows:

Carbon	0.17/0.24%
Manganese	0.60/0.95%
Nickel	0.35/0.75%
Chromium	0.35/0.65%
Molybdenum	0.15/0.25%

In other words, the steelmaker by getting a 2-point leeway in carbon, a 15-point leeway in manganese, a 10-point leeway in nickel, and a 10-point leeway in chromium can deliver a steel more closely controlled than under the chemical composition method of specifying.

The reason for this apparent anomaly is the fact that he can apply probability to alloy balance together with the most modern methods of control before the heat has reached ingot form. Shortly before tapping the heat chemical compositions are run. With that information the melter can adjust his alloy additions to bring the steel within the desired hardenability range. But he could not achieve the same results under the more closely stipulated chemical composition method.

For example, if, in making a heat of 8620H, the preliminary chemical analysis showed nickel and molybdenum to be toward the high side of the permissible range, the melter in making an "H" steel can reduce the amount of manganese or chromium, or both, added in order to bring the steel within hardenability specifications. Similarly, the added flexi-

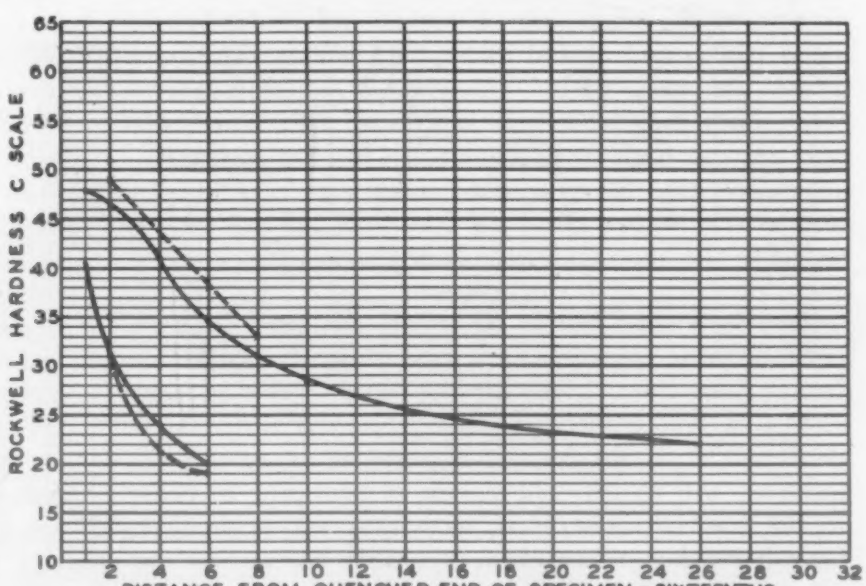


Fig. 1—Tentative hardenability band for 8620 H. The dotted line is for standard chemical composition; the solid line 8620 H.

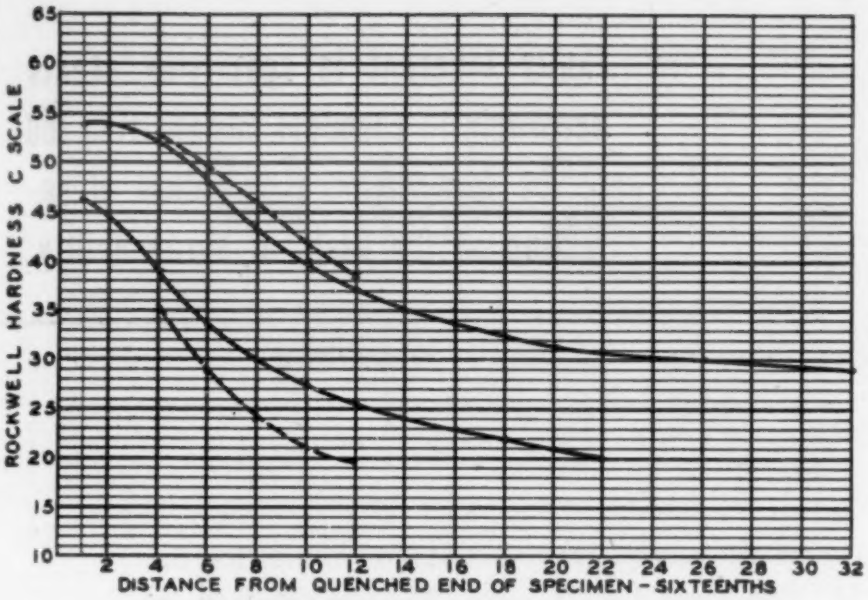


Fig. 2—Tentative hardenability band for 4130 H. The dotted line is for standard chemical composition 4130; the solid line 4130 H.

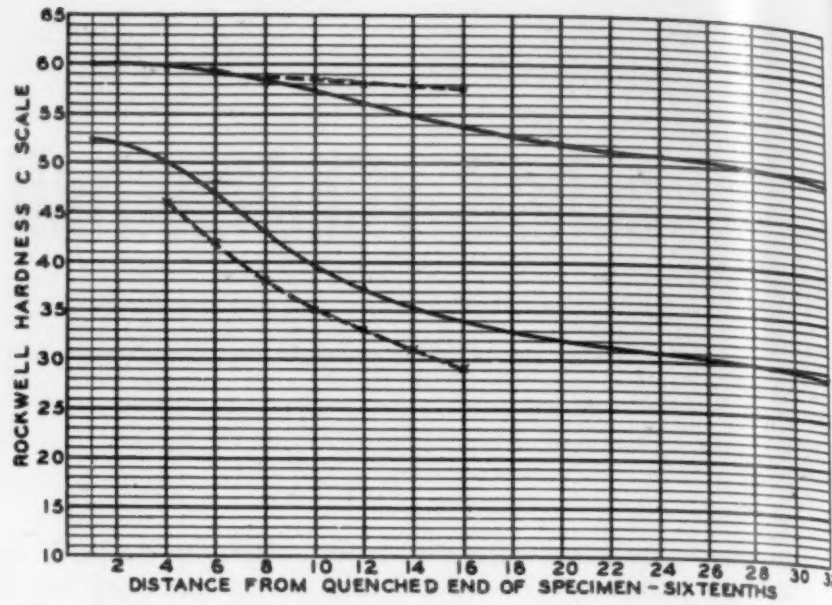


Fig. 3—Tentative hardenability band for 4140 H. The dotted line is for standard chemical composition; the solid line 4140 H.

Table I—Chemical Composition Limits for Steels Shown in Hardenability Bands, Figs. 1 to 5, Inclusive.

Steel Designation	Chemical Composition, %					
	C	Mn	Si	Ni	Cr	Mo
8620	0.18/0.23	0.70/0.90	0.20/0.35	0.40/0.70	0.40/0.60	0.15/0.25
8620 H	0.17/0.24	0.60/0.95	0.20/0.35	0.35/0.75	0.35/0.65	0.15/0.25
4130	0.28/0.33	0.40/0.60	0.20/0.35	—	0.80/1.10	0.15/0.25
4130 H	0.27/0.34	0.35/0.65	0.20/0.35	—	0.80/1.15	0.15/0.25
4140	0.38/0.43	0.75/1.00	0.20/0.35	—	0.80/1.10	0.15/0.25
4140 H	0.37/0.45	0.70/1.05	0.20/0.35	—	0.80/1.15	0.15/0.25
4620	0.17/0.22	0.45/0.65	0.20/0.35	1.65/2.00	—	0.20/0.30
4620 H	0.17/0.24	0.40/0.70	0.20/0.35	1.50/2.00	—	0.20/0.30
8630	0.28/0.33	0.70/0.90	0.20/0.35	0.40/0.70	0.40/0.60	0.15/0.25
8630 H	0.27/0.34	0.60/0.95	0.20/0.35	0.35/0.75	0.35/0.65	0.15/0.25

bility due to wider chemistry ranges enables the melter to balance heats which would tend toward the low side in hardenability by working to higher manganese or chromium limits, or both.

In making a heat to chemistry only, however, he is required to have all elements within the narrower ranges to avoid off-heats. Consequently, if the heat is toward the high side of nickel and molybdenum, he is still bound to add manganese and chromium to bring the steel within the chemistry specifications. The result may be a heat within all chemical limits and yet too high in hardenability for the consumer's intended use. Reverse conditions can also prevail, and a heat within chemical specifications can be too soft for the intended use. Indeed, that condition is more prevalent than the reverse.

In the normal course of events the steel industry expects some consumers to want closer hardenability limits than those given in the published standards, just as a few years ago closer chemical limits were demanded. As production experience is gained the industry will modify the bands, if possible. In order to do that, however, it is necessary that steelmakers have mass data taken on comparable bases. For that reason, consumers should endeavor to specify hardenability according to standard methods so that exact statistical techniques can be used to adjust the bands to the best advantage of both producer and consumer.

At the present time the Technical Committee on Alloy Steel of the American Iron & Steel Institute and the Iron & Steel Technical Committee of the Society of Automotive Engineers are at work analyzing data on hundreds of heats of "H" steel which have been produced since the first tentative hardenability bands were published. The indications are that some of the bands will be narrowed.

In addition to the studies previously mentioned, the committees are preparing for publication hardenability bands for many steels which were not in common use during the war because of their high strategic alloy content.

At this point it may be well to review the various methods of specifying the hardenability of a standard "H" steel. It is recommended that two points be used to designate the desired hardenability. Those two points may be specified in any one of the following ways:

A. *The minimum and maximum distances at which any desired hardness value occurs.* This method

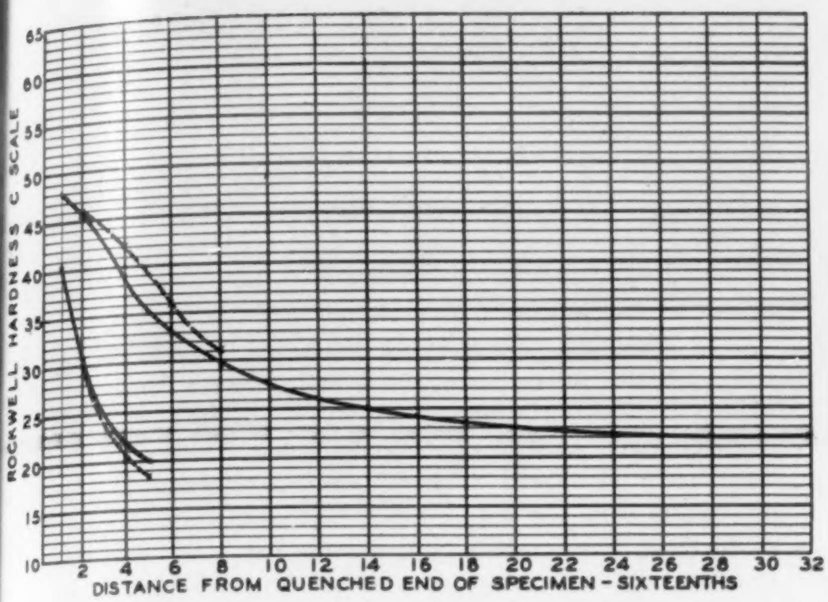


Fig. 4—Tentative hardenability band for 4628 H. The dotted line is for standard chemical composition; the solid line 4628 H.

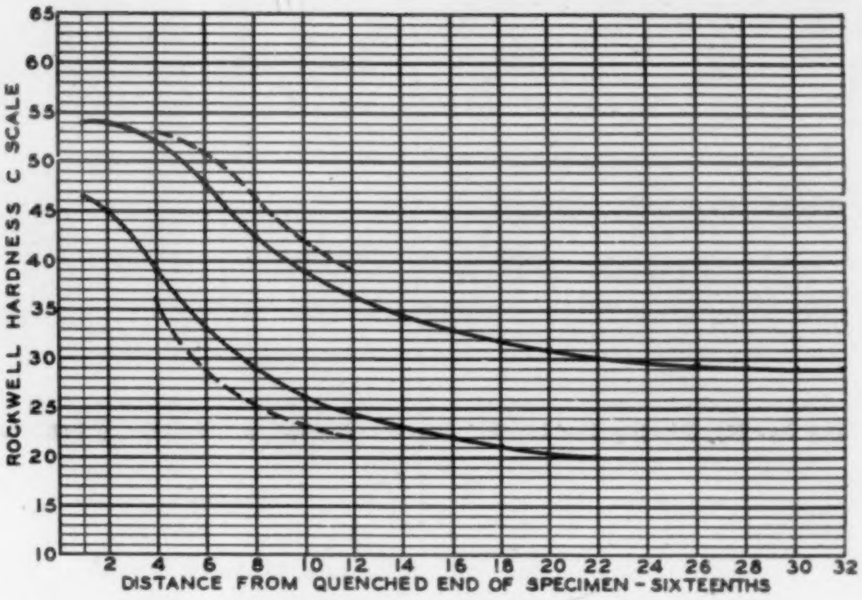


Fig. 5—Tentative hardenability band for 8630 H. The dotted line is for standard chemical composition; the solid line 8630 H.

is illustrated in Fig. 6 as points A-A and is commonly written $J_{45} = 4/11$ sixteenths.

B. *The minimum and maximum hardness values at any desired distance.* This method is illustrated in Fig. 6 as points B-B and is commonly written $J_{36/50} = 8$ sixteenths. Obviously, the distance selected would be that distance on the end-quench test bar which corresponds to the section size used.

C. *Two maximum hardness values at two desired distances* as shown in Fig. 6 as points C-C.

D. *Two minimum hardness values at two desired distances* as shown in Fig. 6 as points D-D.

E. *Any point on the minimum hardenability curve plus any point on the maximum curve.*

When it is considered necessary, the maximum and minimum values at the 1/16-in. point can be specified in addition to those previously discussed.

When it is necessary to specify more than two points from the hardenability band (exclusive of the maximum and/or minimum limits at 1/16 in.), a tolerance of two points Rockwell C over any small portion of either curve is necessary as shown by curves X in Fig. 6.

The experience of a large producer of agricultural machinery is summed up as follows:

"Before going to the H steels, we accumulated considerable data on the alloy steels which were being supplied to us on a chemistry specification. Hardenability curves were developed for each heat of steel and from these curves we worked up bands which covered the steels that had been supplied to us over a period of time.

"We were then able to sell our Engineering Departments on the proposition of changing our specifications to permit the wider chemistry which would, in turn, enable us to secure narrower ranges of hardenability. We have continued making hardenability tests on each heat of steel and we can say that all of the heats of steel that we have purchased on the H specification have come within the specified bands. We can definitely say that we are obtaining a closer range of hardenability by the use of the H steels.

"In specifying requirements to the mills, we use method A. In addition, the maximum and minimum limits at 1/16 in. are included. Examples for car-

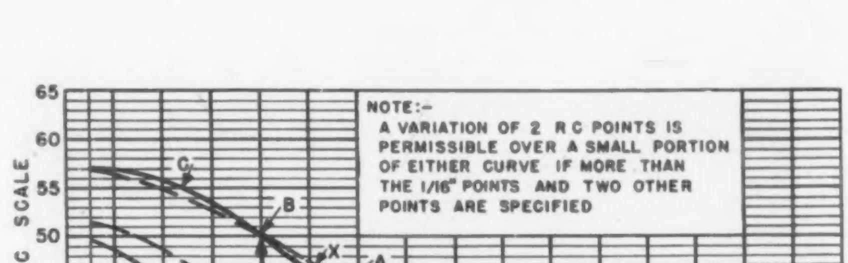


Fig. 6—Methods of specifying hardenability requirements.

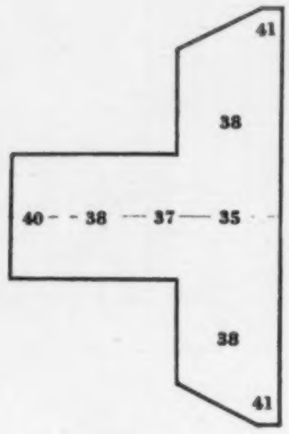


Fig. 7—Section through a gear blank. Numerals indicate Rockwell C values.

burizing and full hardening steels are shown below."

Steel	*Hardenability Specification*
8620H	40.5-48.0 at 1/16 in.; J30 = 2-9
8640H	52.5-60.0 at 1/16 in.; J45 = 5.5-13

The use of hardenability bands rather than straight chemical composition limits will impose upon the consumer of steel the necessity for examining each steel part made in his shop, determining the hardnesses of critical areas of those parts and comparing them with the hardnesses shown on the end-quench curve for the same steel.

In spite of the seeming complexity of this job it is one which can be done without elaborate equipment and one which will pay substantial dividends to the man who adopts the idea and carries it out faithfully. A simple example will suggest its possibilities.

Assume that it is desired to select a steel for the gear blank shown in Fig. 7. To do that it is necessary to make a gear blank out of steel which will not harden all the way through because it is important to secure a wide range of hardness values. The blank is then heated to proper hardening temperature and quenched. It is then sectioned and Rockwell C hardness values taken at all important points as shown in Fig. 7.

It is then necessary to make an end-quench test of the same steel using the recommended S.A.E. test procedure. It is important that the S.A.E. recommended quenching temperatures be used because the standard A.I.S.I.-S.A.E. hardenability bands are based on these temperatures[2].

The hardness values taken from the various positions on the gear blank are matched with hardness values on the end-quench curve, Fig. 8, and the corresponding distances on the end quench test are established. This will give a working correlation for the blank and the end-quench test but only for the quenching temperature and media used. If another quenching temperature or media must be used, the whole test procedure must be run again using the new conditions.

The correlation established can now be used to determine the hardness values which different steels will develop at given points in the blank under the same conditions as were used in quenching the test object.

Rockwell C Hardness on Test Part	*Corresponding Distance on End Quench Test (Sixteenths)*	*Necessary Hardness Pattern*
41	1	48
40	1.5	48
38	2.8	46
37	3.1	44
35	4	40

Examination of hardenability bands published by A.I.S.I.-S.A.E.[2] shows that steel numbers 4135H, 8635H, 8735H, or 9437H will do the job because the hardness values at the corresponding distances shown above equal or exceed the necessary hardness pattern values. The proper steel can then be selected on the basis of cost and fabricating conditions.

References

[1] *ASM Transactions*, Vol. 26, June 1938, pp. 574-599, and disc., pp. 599-606: "Hardenability Test for Carburizing Steel," by W. E. Jominy and A. L. Boegehold.

[2] A.I.S.I.—S.A.E. Contributions to the Metallurgy of Steel—No. 11, March 1947.

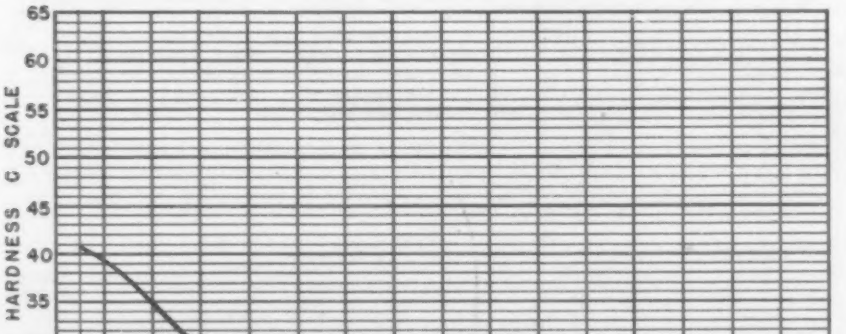
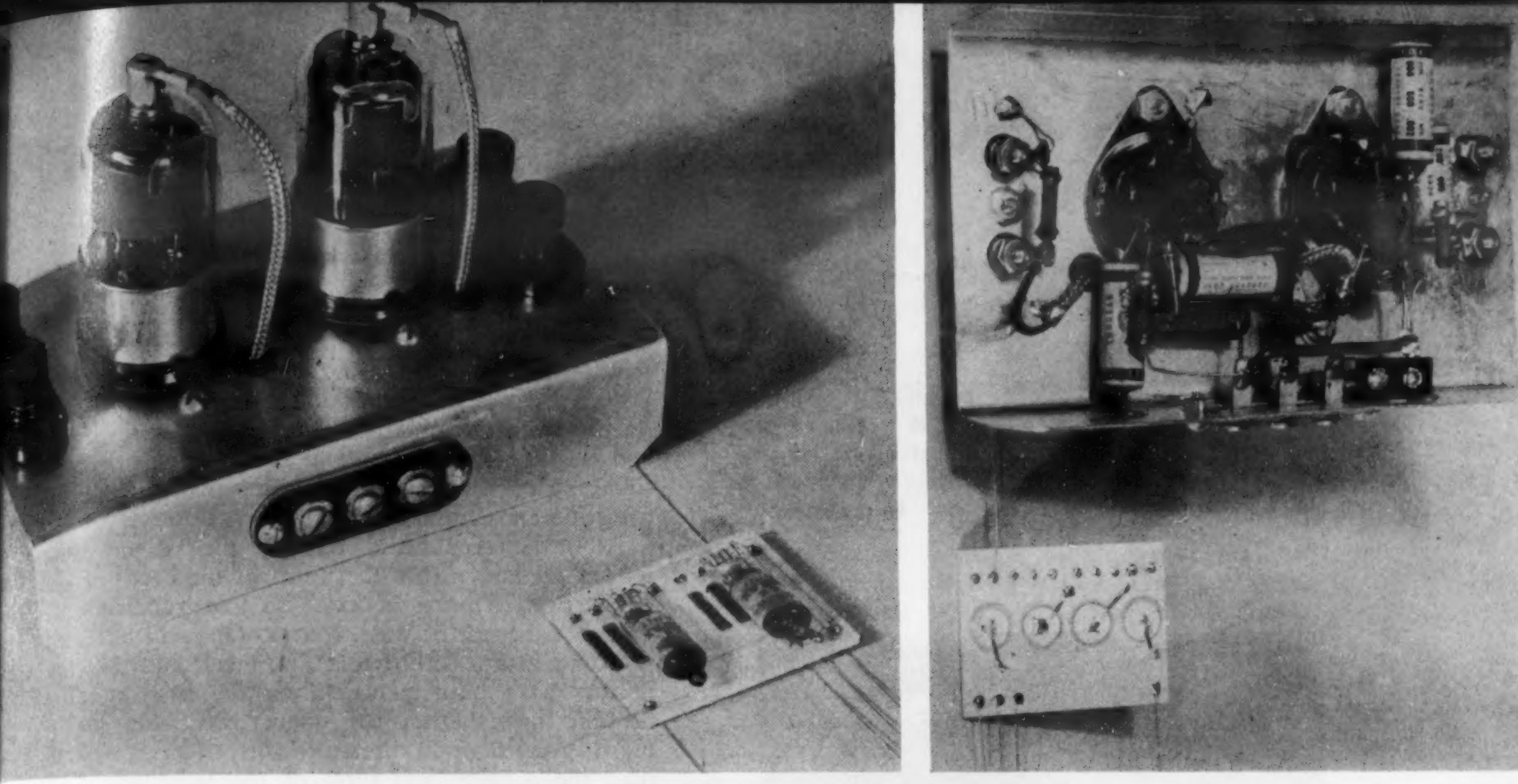


Fig. 8—Hardenability curve of the test steel used for a gear blank.



Compared here, from both top and bottom, are the same circuit assemblies using the old and new methods. (All photos courtesy of Globe-Union, Inc.)

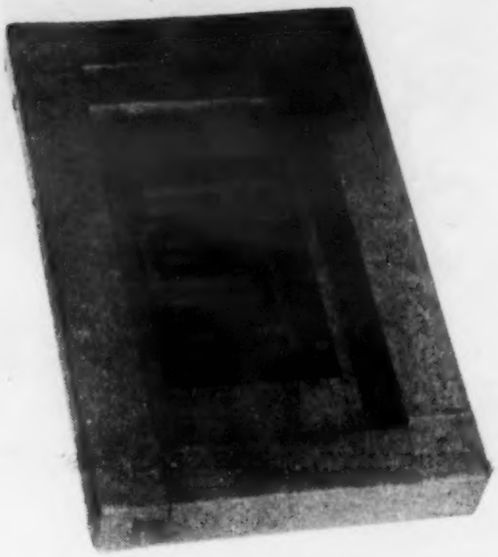
Materials and Techniques for Printed Electrical Circuits

by KENNETH ROSE, *Engineering Editor,* MATERIALS & METHODS

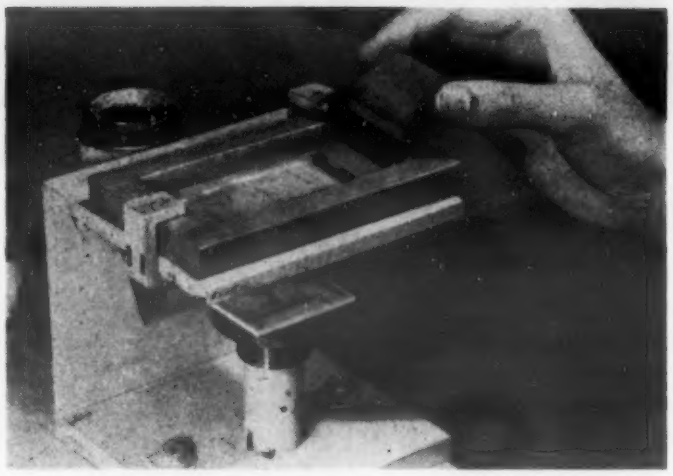
Ceramic sheets with electrical conductors and resistors printed on them permit production of unbelievably small radio and electronic instruments.

MATERIALS FOR THE conventional radio set are rather thoroughly standardized in the light of requirements of the set and of its components. Tubes for detection and amplification, condensers, resistors, inductances, and the conductors to connect them are familiar items in radio receiving and transmitting sets and other electronic devices, and they have taken on a definite form, with a narrow choice of materials for their construction. Copper, for instance, is an overwhelming favorite for the ordinary electrical conductor.

When the proximity fuze, one of America's "top secret" war weapons, was being developed, the primary requirement was a radio transmitting and receiving set that could send out impulses during the flight of the projectile and detect those reflected impulses as the missle neared another object. The projectile was to be detonated when reflected waves were picked up. Power was for set operation to be supplied by an air turbine and generator in the fuze. While the theory involved nothing new, the size requirements for such a set made necessary a complete re-



Silk screens are prepared with the pattern of the circuit to be produced.



Silver paste is forced through the silk screen to place the circuit on a steatite sheet.

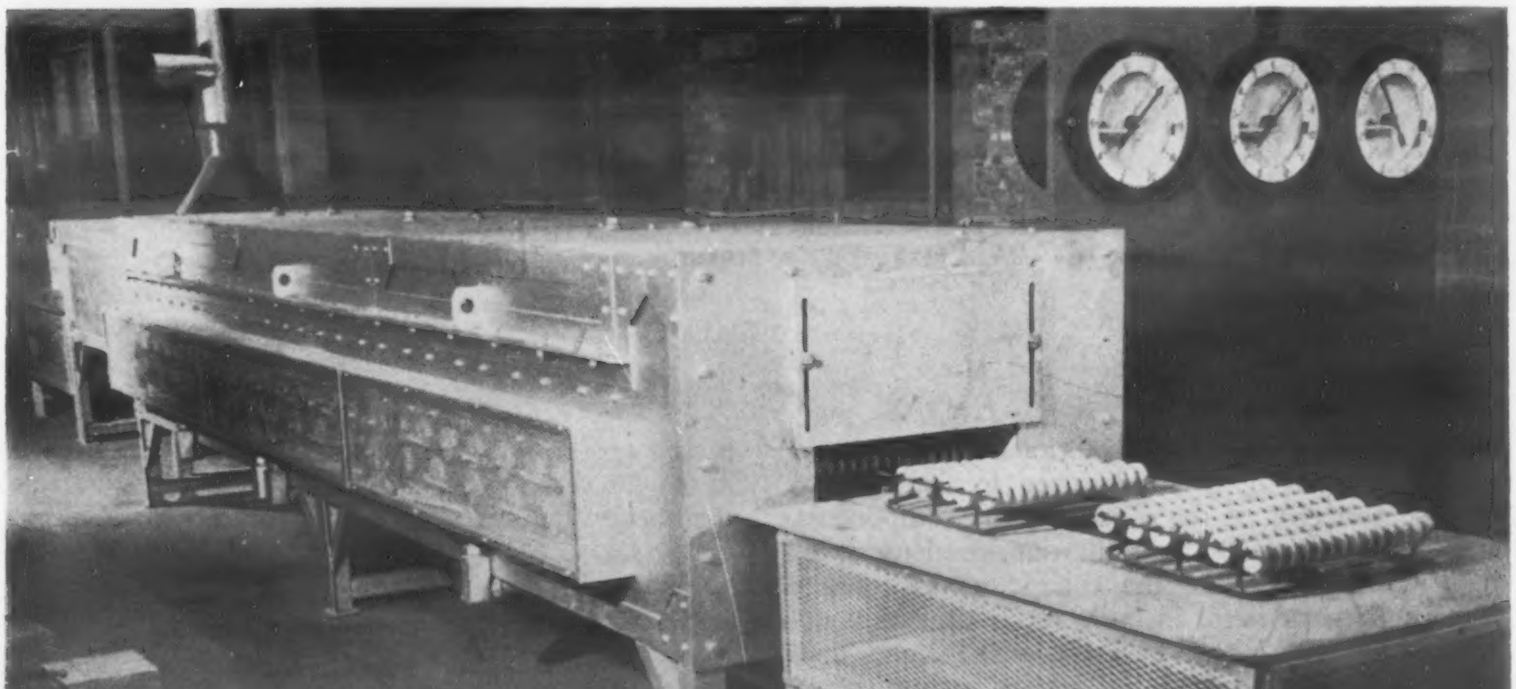
vision of all the customary materials and methods of construction.

The set as finally produced makes use of conductors and resistors, printed on a thin sheet of ceramic steatite, the entire set being only the size of several postage stamps. Metallic and carbonaceous deposits on the steatite form the circuit and its components, and tiny tubes, made without bases and installed by soldering the leads to the metallic paths, provide for detection and amplification.

All of the components present in the ordinary radio set are present, within the limits of the needs of the application. Tuning is fixed, so that variable condensers need not be used. Each component has been prepared in a modified form, however, and the connectors have been stencilled on the base plate as metallic lines, the finished product resembling a wiring diagram done in miniature with silver ink rather than the conventional form of the radio set. This method of construction has been appropriately called "eliminating the third dimension" in the radio set.

Steatite Plate Used

The chassis in the standard set becomes a simple plate of steatite for the proximity fuze radio. An excellent insulator, steatite is not harmed by the firing of the printed plates, nor by the soldering operations that are used to attach tubes and capacitors. It also permits mass production methods of printing the



Finally, the steatite sheet, with the circuit connections stencilled on it, is fired in an oven to form a bond between the metallic silver and the steatite base.

circuits, as it is rigid and easily handled.

Steatite, compounded of refined talcs and clays, possesses several advantages over porcelain for this work, its users claim. These are:

(1) Greater physical strength and hardness.

(2) Nonabsorbent even though completely submerged in water, common solvents, or acids.

(3) Better electrical characteristics even under adverse conditions.

(4) Can be formed to closer tolerances.

While the steatite can be formed in several different ways, such as extruding, pressing, or casting, the dry pressing method is usually preferred because it lends itself to rapid and automatic fabrication. If the form to be produced is so complicated that the almost dry powder will not flow readily into all parts of the mold, wet pressing must be used. Pressures for dry pressing are approximately 10,000 to 20,000 psi., whereas wet pressing can be done at 1000 to 4000 psi. The steatite mixture is carefully ground and mixed in large mullers, with small amounts of fluxes, organic binders, and water added, before forming. After forming, a glaze-producing coating can be sprayed on or otherwise applied if a glazed surface is desired.

The formed steatite is next fired in a continuous rotary tunnel kiln to vitrify the piece. A preheating cycle is followed by the vitrifying heat, which may be as high as 2400 F, and then by a cooling period. About 24 hr. is required for the complete firing cycle. The steatite can be machined without difficulty after forming on the hydraulic presses and before firing, but after vitrification it is amenable to grinding or abrasive sawing only.

Resistance is provided in the circuit by the silk screen process or by spraying. Masks control resistor size.

Printed Silver Replaces Copper Wire

One of the most interesting processes, and the one most distinctive of the fabrication of these small radios, is the printing of the circuits. This is a means whereby connectors of metallic silver are imprinted on the steatite plate, serving the purpose of ordinary copper wire in the conventional set. The silver is laid down as a paste containing either finely divided metallic silver or silver oxide, with binders and solvents of various sorts to suspend the metallic ingredient. The binder is burned off in a furnace following the printing of the circuit, and the silver conductors are left adhering to the plate, just as the pigment in an ordinary printing ink remains after the vehicle in which it was suspended is removed by drying.

For printing the circuits the fabricators resort to a method familiar to the commercial artist—the silk screen method of stencilling. A sheet of fine mesh silk, coated with an impervious material that can be stripped off as desired, has the pattern for the circuit laid out on it, and the impervious material is then removed from those lines that will form the paths of the silver conductors. As the silk mesh remains, the stencil may have completely isolated areas, something not possible with the ordinary type of stencil. The screen is mounted in a frame of wood or steel to give accurate positioning.

The stencil can be prepared photographically by using a light-sensitive coating for the silk, and printing the design from a photographic positive. Gelatin or polyvinyl alcohol, sensitized with potassium dichromate, are such coatings. After printing the design onto the sensitized coating from a photographic positive by exposing to light, the design, shielded from the light and therefore still soluble in water, is washed out.

In use, a steatite plate is placed under the frame holding the silk screen, and the silver paste is squeezed through the mesh of the silk by a "squeegee," a bar faced with neoprene rubber. The complete circuit connections are thus stencilled on the plate in one operation, by a method that is simple and rapid, and that permits an indefinite number of exact duplicates to be made. No expensive equipment is required, and no special skills are necessary in the operator. In order that the paste can be printed evenly and that a good bond to the base may result, the steatite plate must be clean.

Firing in an oven at 1300 to 1500 F burns off the vehicle and firmly bonds the metallic silver to the steatite base. It has been estimated that the bond possesses a tensile strength of about 3,000 psi.

Other Materials Employed

Fixed resistors are added to the circuit in much the same way as the conductors. A heavy paint contain-

ing finely divided carbon as the conducting material, and along with it an inert filler, with solvent and binder, can be applied by the silk screen process, or by spraying. Resistance is controlled by varying the length and width of the applied paint strip, or by varying the proportions of carbon and inert filler in the paint. Masks are used to control the size of the resistors at the time of application of the paint.

After the painted-on resistors have air dried, the masks are removed and the plate is placed in an oven for several hours, at 300 F, to stabilize the resistor. A special resin coating is applied to reduce the effects of humidity. Tests have shown that these applied resistors are stable and accurate under such conditions as high humidity and extreme load. They have been produced in sizes ranging from 3 ohms to 200 megohms.

Other elements of the circuit, the capacitors and the amplifying tubes make necessary a departure from the virtually two-dimensional scheme for the simpler elements. Capacitors of special type replace the standard model condensers. These capacitors are prepared by silvering both sides of tiny wafers of a titanium dioxide ceramic, of from ⅛- to ⅜-in. dia., and of a thickness only slightly greater than that of a piece of paper. By varying the thickness of the ceramic used as the dielectric, as well as its composition, and the size of the silvered area, the capacitance of the tiny unit can be adjusted to desired values. Those produced at present are in the range of 6.5 to 2000 micro-microfarads.

The capacitors are installed in the circuit by soldering them to the silver conductors. Two problems are presented at once — the need for a solder that will not absorb silver from the printed paths on the ceramic base, and the need for a lower-temperature soldering operation so that the thin ceramic wafers used as a dielectric will not be broken by the heat. Dissolving of the silver is obviated by using a solder with a silver content of at least 2%. To reduce the temperature needed for soldering, a special low-melting bismuth solder is used for the operation.

Capacitors and tubes of special size and construction are soldered in place to complete the assemblies.

Tiny Parts Require Special Methods

Tubes for the radio, to be in proportion with the rest of the set, must be smaller than even the miniature tubes developed for other applications. Several of the leading tube manufacturers produced a special subminiature tube, about 1 in. long, rugged, efficient, and with very low filament drain. A variety of tube types is available in this very small size, so that most ordinary circuits can be duplicated in the "two-dimensional" type of set.

Installation is made by soldering the leads of the tube, which are taken directly through the glass envelope instead of being led through a base, to the printed conductors. The same precautions must be observed as for other soldering operations with these circuits.

In the proximity fuze, the set is auto-powered with a turbo-generator designed to operate at speeds of 100,000 rpm. and higher. A die cast rotor, carefully balanced, was actuated by the passage of the projectile through the air. The entire fuze, with its radio transmitting and receiving sets, amplifier and control circuits, and power plant, is contained in a space approximately 5 in. long and 3 in. in dia. Components for the fuze were developed by engineers for Centralab Division of Globe Union, Inc., and scientists of the National Bureau of Standards.

The techniques that made the proximity fuze possible will not be discarded when production of that weapon ends. Pocket radios are already being developed by several companies. Hearing aids making use of electronic amplification of sound can be reduced in size by use of the new circuits. Various electronic controls used in industry can be reduced in size or weight if such reduction is desirable. Meteorological instruments to be sent aloft by the kites or baloons now in use may be made lighter in weight.

A feature of the new type of circuit is the fact that it can be used in conjunction with the standard electronic components in most cases. The printed circuits are limited to low power applications, but within this limitation standard parts can be soldered into place in the circuit if desired. Likewise, a unit circuit with all its miniature components can be installed in an electronic device along with other circuits of standard size, facilitating replacement of the circuit as a whole, or reducing size or weight in a given portion of the device.

Additional controls in miniature are now in process of development for use with standard-size radios. A knob containing within itself an "on-off" switch and step volume control will go into table models as an added convenience in assembling, and to bring these functions into one circuit. Similar developments are promised in other lines as the technique is given wider application.

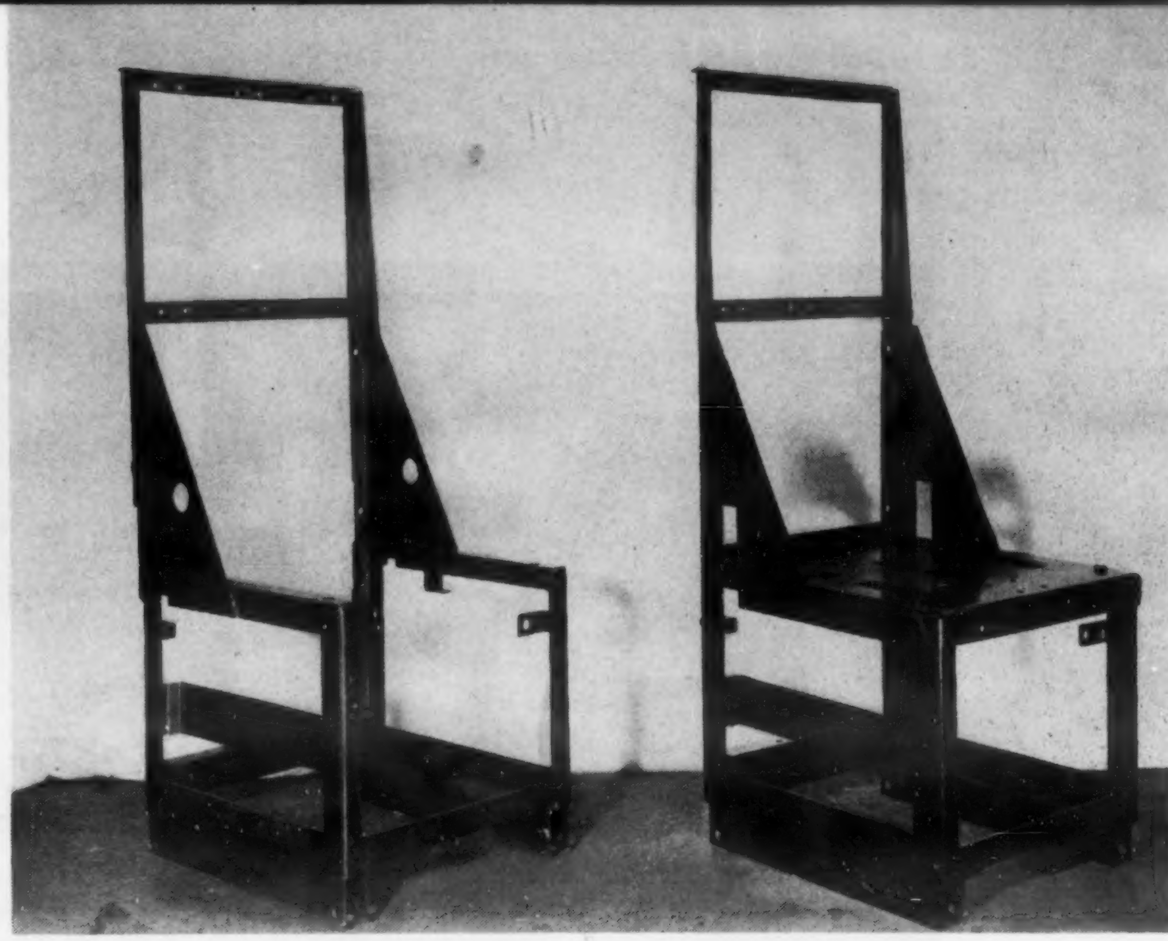


Fig. 1—At the left is shown an arc welded structure. Simplification is achieved in the similar assembly (right) by resistance welding side assemblies and then arc welding the cross-tie members.

Case Histories Show Versatility of Resistance Welding

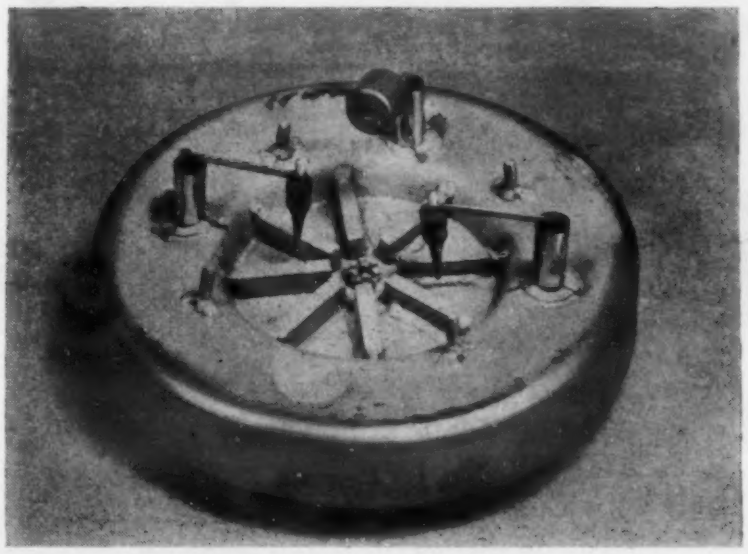
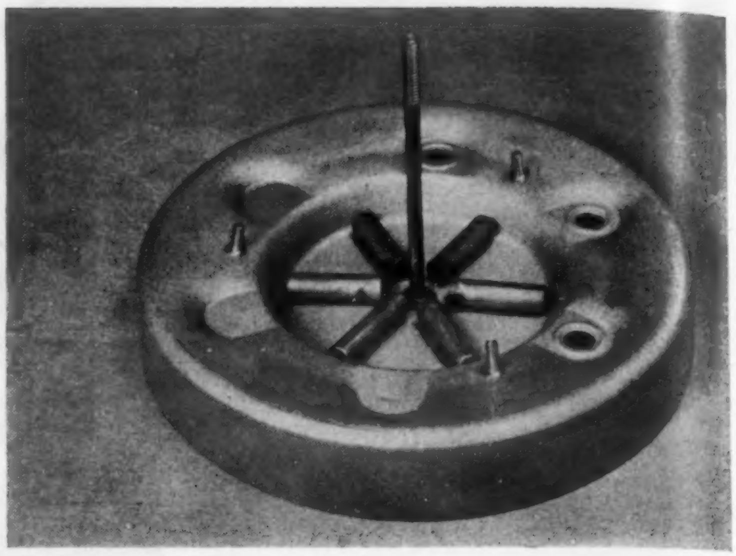
by JOSEPH W. KEHOE, *Divisional Staff Supervisor, Headquarters Mfg. Engrg. Dept., Westinghouse Electric Corp.*

> **Shown and described here are several examples of the intelligent application of resistance welding to achieve better products and reduced production costs.**

Among the better known methods of resistance welding are spot, seam, projection, butt, flash and percussion welding. Quality, economy, and speed, but above all versatility, are the chief advantages obtained from the application of these resistance welding methods. For, while it is often the only acceptable solution to a metals joining application, resistance welding can well be used in conjunction with other fabricating methods, and often results in better appearance, less distortion, and accomplishes savings in brazing alloy, fuel and die costs, material and assembly time. Furthermore, proper design, tooling and welding equipment permit resistance welding to compete favorably with any other metals joining method. Some examples of these advantages of resistance welding are cited in the following paragraphs.

Avoiding of distortion, warpage, and leakage is of major importance in the seal-off operation on large vacuum tubes. This can most easily be accomplished by spot welding the preformed tube. A similar and well-known problem is solved in the spotwelding of tungsten and molybdenum parts for vacuum tubes.

In combination with other joining methods, the use of resistance welding has proved most economical. The truck structures in Fig. 1 illustrate the simplification that can be attained by such a combination. To the left is the difficult-to-assemble arc welded structure. The advantage obtained from resistance welding the side assemblies and then joining the cross-tie members by arc welding in the final assembly, as shown to the right, was that despite the difference in joint thickness it could be welded entirely on the horizontal plane in one welding fixture and with one resistance welding machine setting, thus permitting

Figs. 2 and 3—Considerable savings were experienced by converting the arc welded tube header (left) to a resistance welded assembly (right). Savings were made in time and materials and at the same time quality was improved.

large savings of material, assembly and welding time.

Quality and economy of product were the important considerations in the case of the tube headers shown in Figs. 2 and 3. However, the advantages as shown in resistance welding (Fig. 3) over arc welding (Fig. 2) in this instance were manifold. The ease of fabrication of the new design led to more consistent and better quality and the resistance method permitted the use of less expensive bolts and round bars. Time was saved and quality improved because a special welding sequence no longer had to be followed and straightening or heat-treating methods could be eliminated.

Savings resulting from the application of resistance welding to what was formerly a plug welding job done by the electric arc or automatic processes of fusion welding are illustrated in Fig. 4. Eliminated operations were the locating and punching of holes in the steel bar stock, grinding of excess weld metal, straightening of the welded assembly, and the need of using longer bars. Again distortion and warpage due to plug welding were avoided as shown in the resistance welded lever arm in Fig. 5, where redesigning for resistance welding resulted in large savings. The use of projections on the end plates of the lever arm has eliminated holes formerly needed to locate the arm with respect to the end plates.

Resistance brazing and soldering, though not generally associated with resistance welding, are true applications of the principle. Soldering operations confined to small places have been considerably expedited by the use of a pair of carbon electrodes which were attached to a small transformer in a vertical pedestal assembly.

A particularly good example of the savings in fuel that may be obtained by the resistance welding method is the resistance brazing job shown in Fig. 6. The bushing in the box in the upper right hand corner was brazed by the use of two carbon electrodes mounted in a standard press welder. The amount of silver alloy was controlled by the use of a silver solder ring preplaced under the head of the bushing. Savings of silver solder were made over the old torch method in which the silver solder was fed manually, and the cost of power to operate the spotwelding machine was only one-ninth the cost of the oxygen and acetylene previously used for torch brazing the bushing. Furthermore, in this same assembly standard spotwelding nuts eliminated the use of a screw-machined nut and could be spotwelded at an electrical power cost of one ninety-secondth of the previous fuel cost.

Again by means of resistance welding, blanking and piercing may be made more economical, as in the case of heavy steel sections, by punching holes in thinner sections with inexpensive dies and welding them together to make up the required thickness. Sections of between 3/16- and 3/8-in. thickness may be impossible to blank or pierce accurately and economically by other methods depending, of course, on the number of holes, shape of the part, accuracy and tolerance requirements between hole centers and other factors, whereas sections built up in the manner described have been found to hold the required tolerances. Fig. 7 shows a spotwelded end plate built up of nine thicknesses of 0.020-in. mild steel, which was formerly made up of three 1/16-in. thicknesses welded together. Another application of the same principle is shown in Fig. 8 where the difficulty of cutting or burning holes in a 3/8-in. thickness was eliminated by spotwelding two 3/16-in. thicknesses of mild steel, which had been previously punched with standard tools. Since the location of the welds was important, their position was determined by cutouts in the welding fixture.

As illustrated in Fig. 9, the necessity of machining items of various shapes out of one solid piece of metal can often be avoided with no loss of strength of the part by means of resistance welding. In the part shown projections located on the side plate are used for welding to the cross bar, which is now made from standard bar stock.

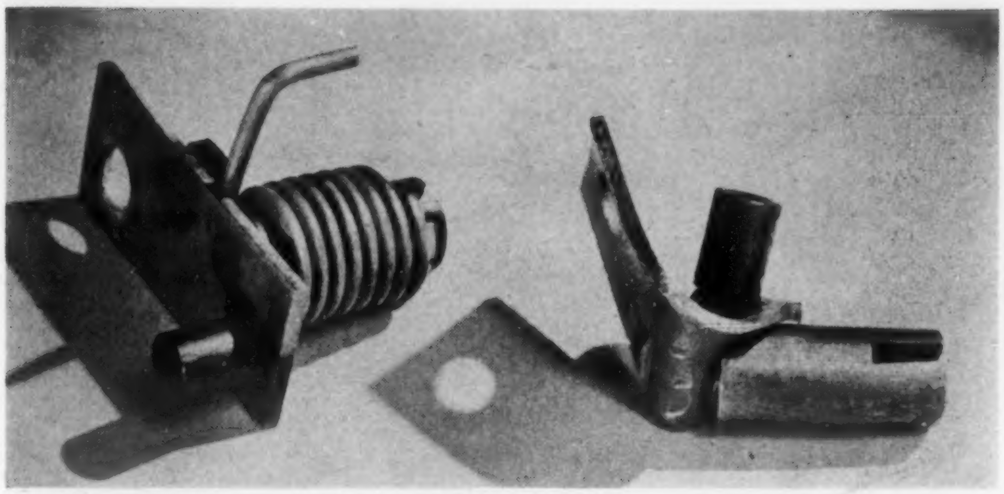


Fig. 4—The strength of resistance welds is demonstrated on the test assembly (right). This assembly was formerly joined by fusion welding.

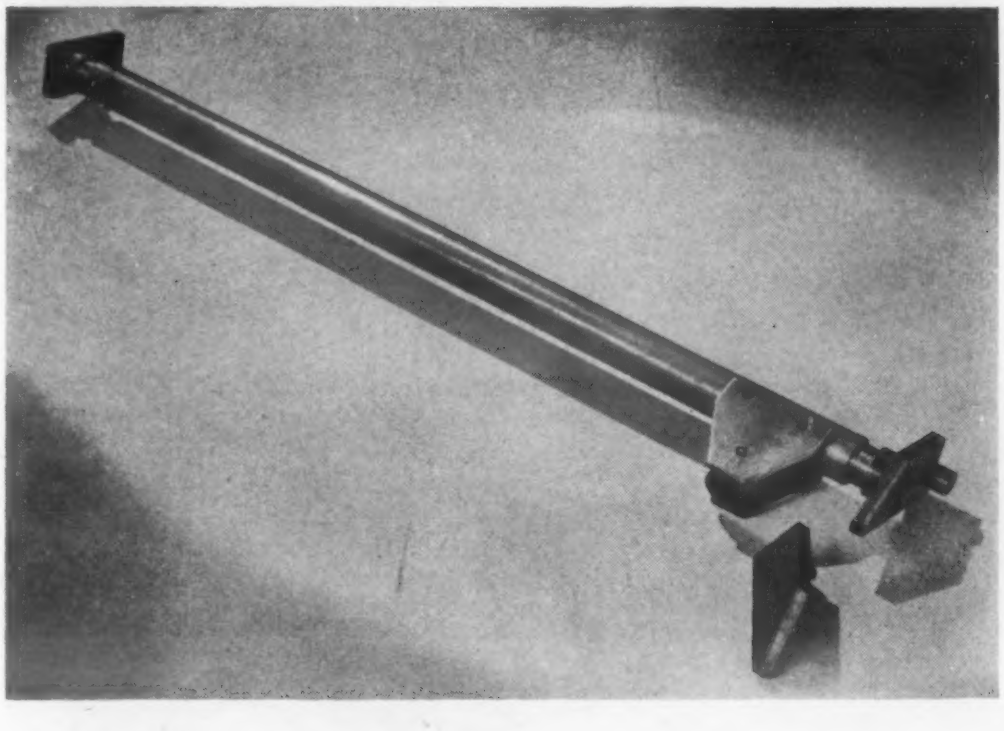


Fig. 5—On this welded lever arm resistance welding overcame distortion and warpage which resulted from former joining methods.

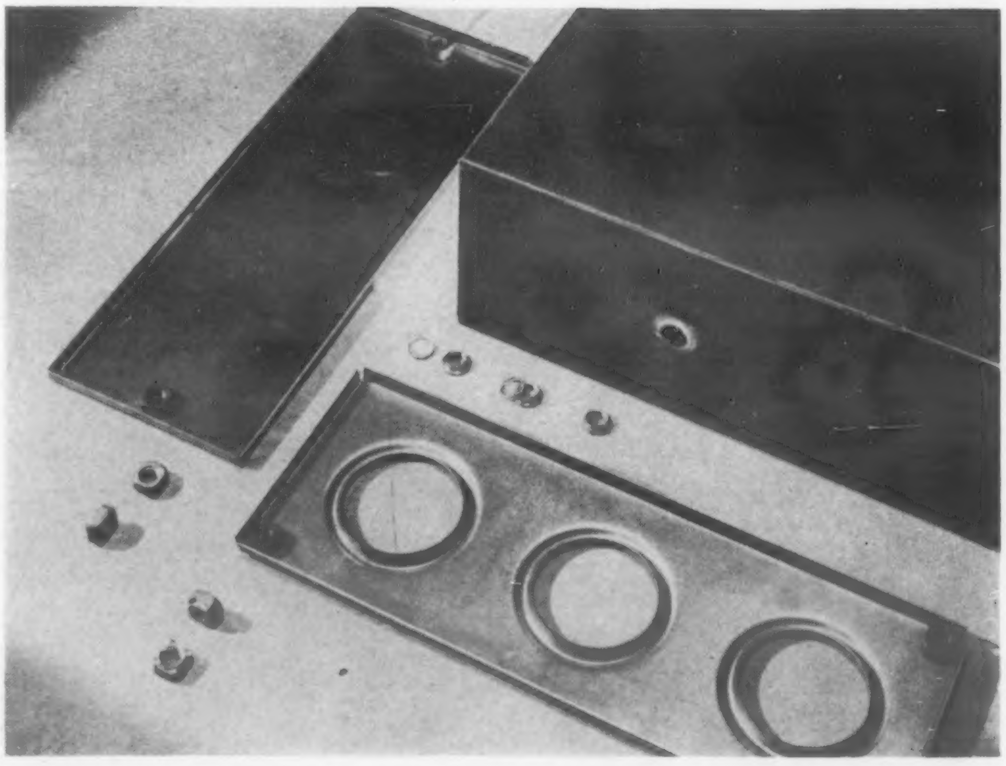


Fig. 6—Through the use of two carbon electrodes mounted in a standard press welder, the bushing in the upper box was silver brazed. Power and alloy costs were reduced over gas brazing formerly used.

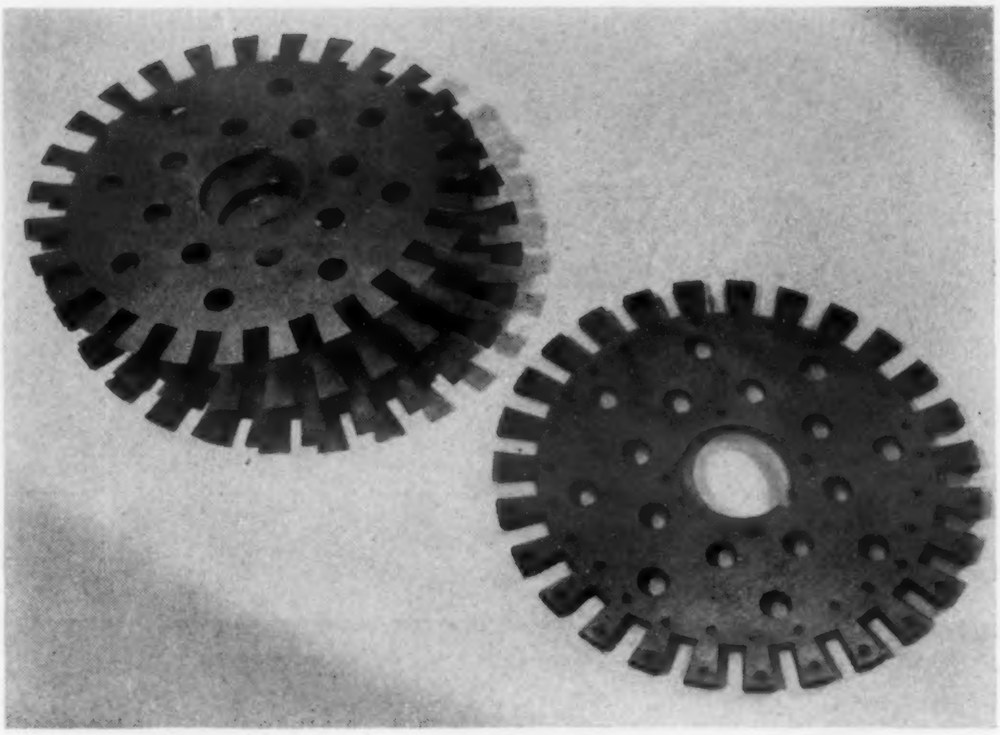


Fig. 7—Nine thicknesses of 0.020-in. mild steel were formed and then spot welded to form this end plate which was formerly made of three 1/16-in. thicknesses welded together.

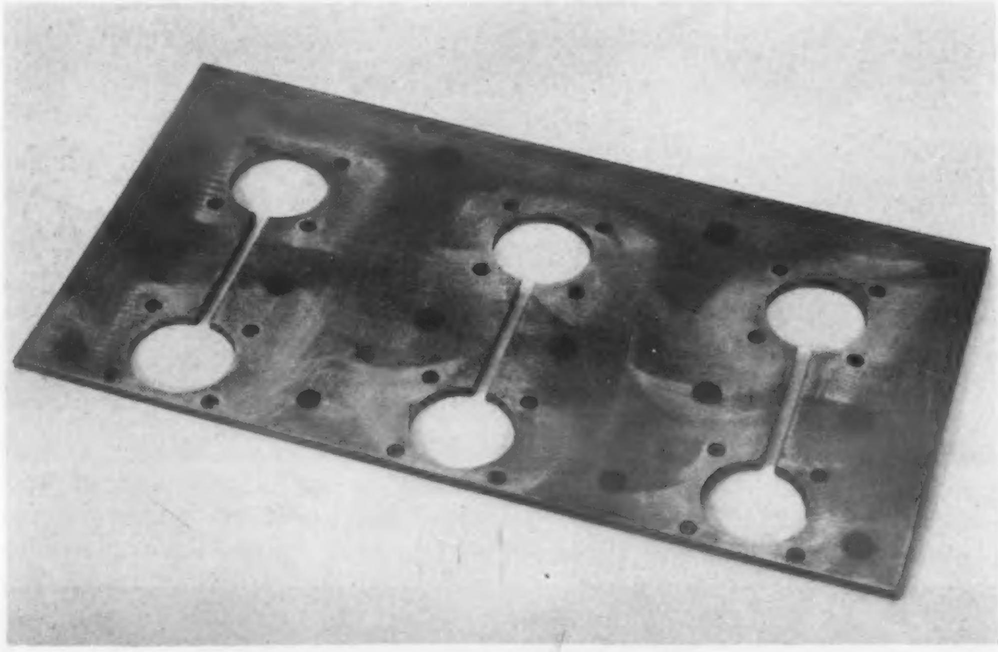


Fig. 8—The difficulty of cutting or burning holes in a 3/8-in. piece of steel was overcome by spot welding together two 3/16-in. thickness of mild steel, which were previously punched with standard tools.

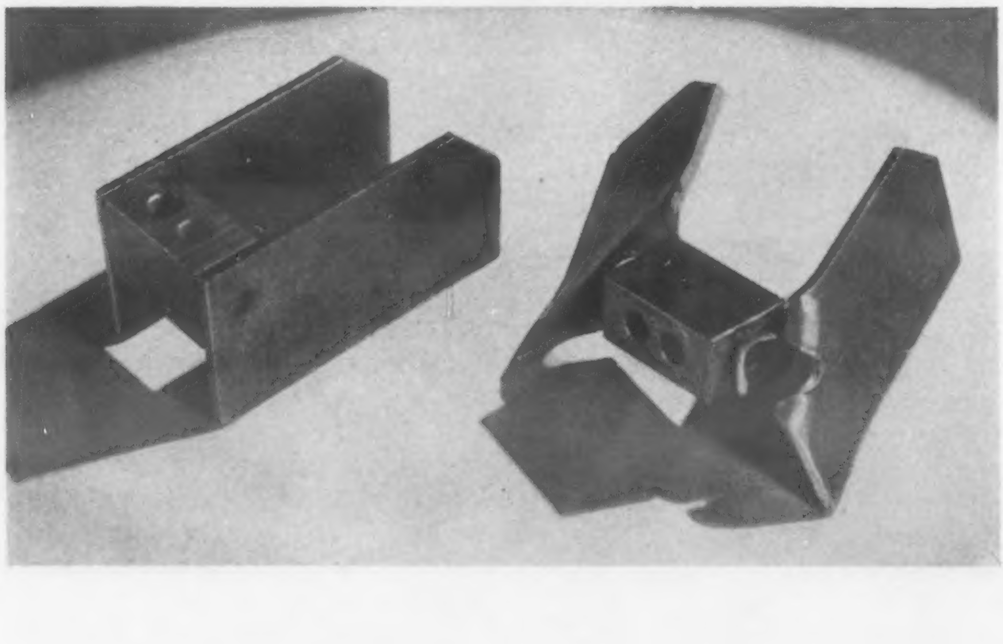


Fig. 9—A costly machining job is eliminated on this unit by joining three simple shapes through resistance welding.

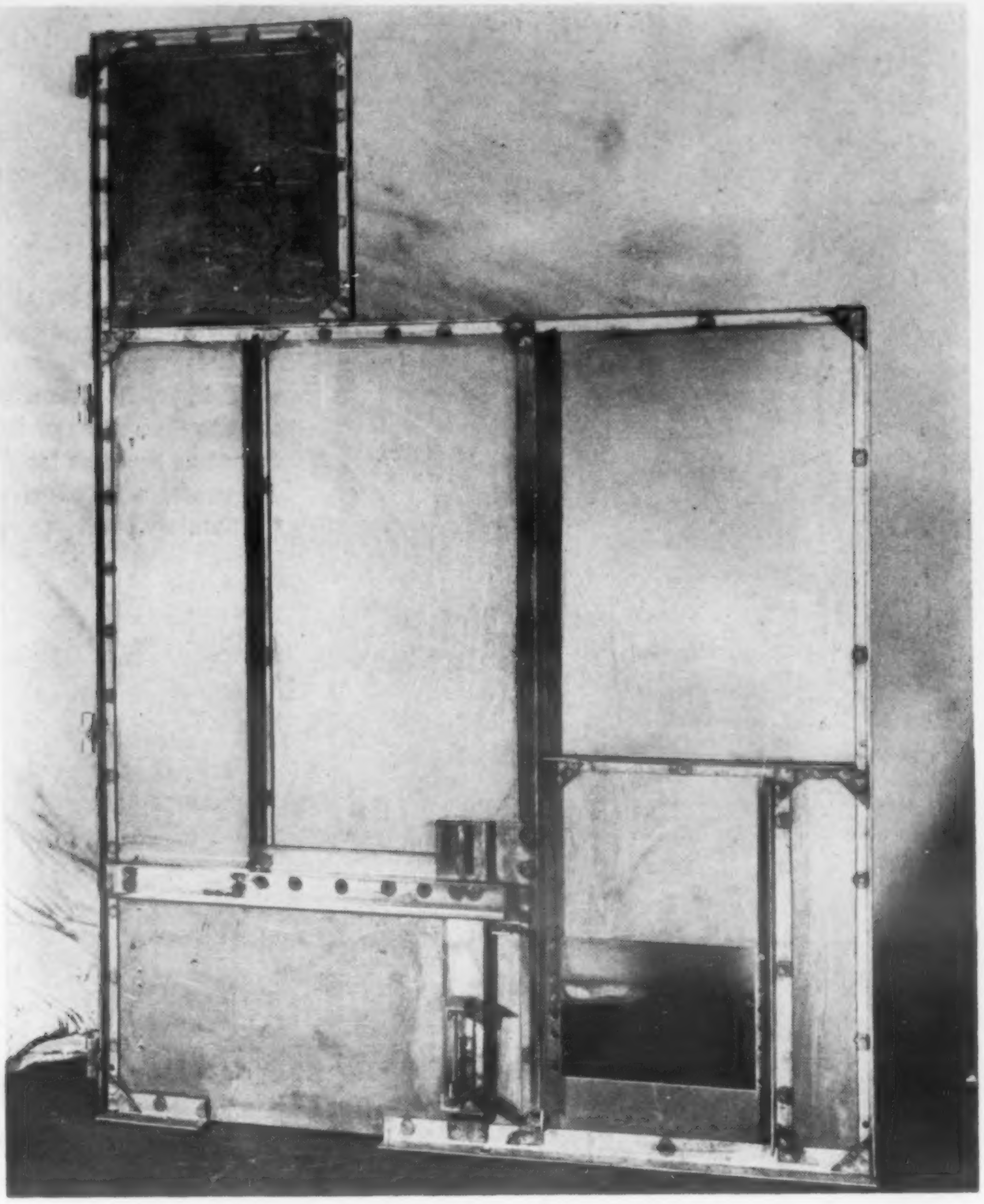


Fig. 10—Deep throated resistance welding machines are used to handle such assemblies as this which measures approximately 70 by 90 in.

Finally, resistance welding is now used on many large structures that had formerly been considered too large or too heavy. With proper design of the structure and of handling equipment, such as large portable ball-top tables and welding fixtures designed with self-locating features that may even locate the sequence of spot-welds, large structures are being successfully handled in deep throat spotwelding machines. The overall dimensions of the spotwelded structure in Fig. 10 are approximately 90 by 70 in. Note the different shapes such as angles, sheets, hinges, bolts, nuts and brackets all welded with one type of electrode.

In summary then, the following are some of the major advantages of resistance welding:

1. Resistance welding is often the only acceptable solution to a metals joining application.
2. Resistance welding can incorporate the other types of metals joining methods so that each application can be a successful application of the best welding method.
3. Resistance welding can improve the quality and economy of the finished product, such as in the illustration of the tube header.
4. Less warpage, less distortion, little or no straightening, no relieving treatments, no grinding, and no locating and punching of holes are obtained when resistance welding is used in place of plug welding.
5. Resistance brazing and soldering will not only save in welding, and in silver alloy costs, but in fuel gas costs as well, when gases are used as the heating medium such as in torch welding, brazing or soldering.
6. Lower die costs and maintenance, less expensive dies, the use of standard punch presses or tools instead of the slow die setups, and a better quality product are obtained in the case of building up to a required thickness by means of spotwelding component thicknesses. This in turn releases the time of the highly skilled tool and die men for other work.
7. Finally, the quality of a resistance welded product need never be inferior to that of any other type of welding on the same application. Proper design, tooling, and welding equipment can enable resistance welding to compare favorably with any other metals joining method.

Here plies of Fiberglas mat, with thermosetting resin poured on, are being pressed into a female mold by a Neoprene plug. The operator holds one of the box-like shapes as it comes from the mold. (All photographs courtesy Owens-Corning Fiberglas Corp.)

Glass Fibers as Engineering Materials

by KENNETH ROSE, *Engineering Editor,* MATERIALS & METHODS

WHEN GLASS FIBERS were first introduced to the public about ten years ago it was their flexibility that caught the attention of the man in the street. Glass had always been a rigid material, and the ease with which it could be shattered had fostered the lay impression that it was weak also. The engineer knew glass as a fairly strong, highly notch-sensitive nonmetallic material, of low but almost entirely elastic deformability, extremely high corrosion resistance, and high hardness, an electrical nonconductor, incombustible, and with a weight slightly below that of aluminum. The news that these properties were now to be made available in a pliable fiber immediately brought up visions of new uses to which the fibers could be put in the industrial picture.

Glass fibers have lived up to expectations. Although much of their existence has been overlapped by the war years, when only needs of the armed forces were regarded as important, they have already become standard for a wide variety of industrial uses. To give a general idea of these uses, and of the engineering properties that fitted them for such applications, with the thought that knowledge of the possibilities may suggest solutions of other of the engineer's problems, is the purpose of this article.

There is no magic about the flexibility of glass in fiber form. If the same glass were presented as a sheet, or in any of the more familiar shapes, its flexibility would disappear. Flexibility is associated with the small diameter of the material in fiber form, just as steel when drawn to a fine wire becomes flexible.

As a fiber glass retains many characteristics of its other forms and adds a few other good ones to make it a highly useful engineering material.

The insulating qualities of Fiberglas are used to advantage in protecting a pipe line.

Glass fibers are produced by two methods:

(1) Exudation and jet attenuation.

(2) Exudation and mechanical attenuation.

By the first method is produced glass fiber in the wool-like form used chiefly for thermal and acoustical insulation, and the staple textile fibers.

When the glass is to be produced in the wool-like form, the batch is melted and refined in a large tank, holding about 40 tons, and the molten glass is then permitted to exude from tiny orifices. Steam from high-velocity jets whips these thin streams of glass downward toward a moving conveyor, at the same time drawing them out into very fine filaments. The glass fibers collect on the conveyor in a wool-like mass, the thickness of which is determined partly by the speed of the conveyor.

Glass textile fibers will start with batch melting and refining in a large tank or furnace, but the glass is first formed into marbles, about ⅝-in. in dia., and inspected. The marbles are then remelted in small electric furnaces, and filaments are produced by one of two processes:

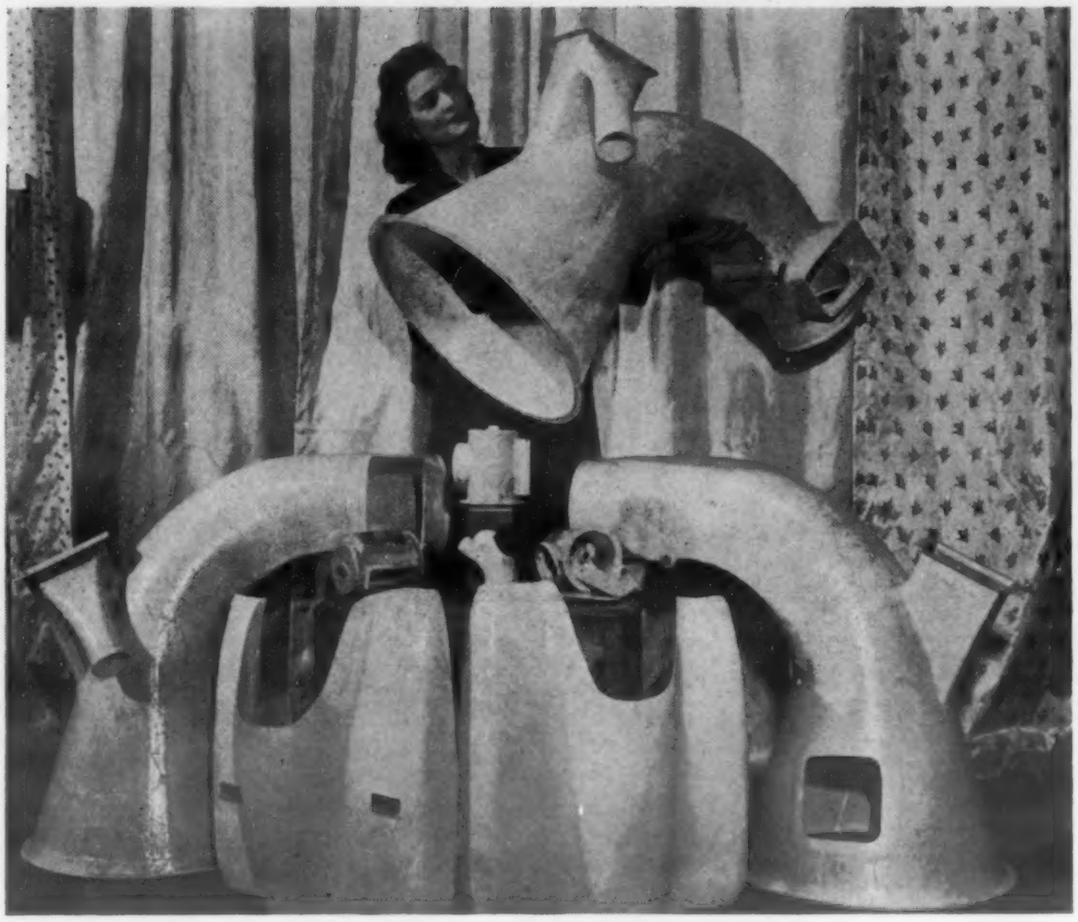
(1) The staple-fiber process, in which the exuding streams of glass are attenuated by a steam or air jet, collected on a revolving drum, and this sliver (pronounced sly'ver) wound on tubes preparatory to twisting into yarns.

(2) The continuous filament process, in which the exuding filaments are pulled down by hand, and drawn together into a strand, further attenuation being provided by a high-speed winder carrying the strands. The strands are later twisted and plied into yarns.

In making yarns by either process, it is necessary to lubricate the filaments to reduce the extent of their abrasion of one another. If the glass cloth is to be impregnated with plastics, or if glass cloth is to be varnished with any of the silicones for use in motor insulation, the lubricant must be removed by a heat treatment.

Properties Similar to Other Glass Forms

The properties of glass fibers are in general the



These Fiberglas-reinforced plastic aircraft parts show how the material can be fabricated to complex shapes. The parts shown were produced by Industrial Plastics Corp.

same as those of glass in other forms. Their property, in textile forms, as nonconductors of electricity is one of the most valuable attributes industrially. Resistance to corrosion by all acids except hydrofluoric and hot phosphoric, and by weak alkalies, makes glass fibers in various forms valuable in the chemical industry, or anywhere in contact with chemicals. Glass fibers found one of their early applications as a retaining mat in storage batteries, and they are one of the best tower packing materials. Noncombustibility, with corresponding temperature endurance, is of major importance in glass fiber textiles, as nearly all the ordinary textiles are of organic origin, and are combustible.

Several properties more immediately related to its wool-like form are its thermal insulating qualities, its sound deadening properties, and its value as a filtering medium. Its efficiency as a heat barrier is dependent upon the trapped air held in the fibrous wool-like mass, and is controllable within limits by regulating the degree of compacting. Its noncombustibility, in combination with heat insulating qualities, makes it especially desirable for elevated temperature applications, such as pipe insulation. Depending upon the type of binder used, it is suitable for use to 300 F, to 600 F, or to 1000 F. Its inorganic nature, giving freedom from decay, makes it desirable in low temperature insulation also.

Sound deadening, or noise reducing ability, is also associated with the wool-like form. For aircraft and similar applications, this noise reducing quality is valuable in combination with noncombustibility and light weight. Its value as a filter medium, in either the chemical industries or air conditioning applications, is associated with its inorganic constitution, in the first case because of its chemical resistance, in the second because of its freedom from deterioration under wet conditions.

Tensile strength of the textile fibers, running to values of the order of 400,000 psi., is stated to be the highest of any material, either natural or man made. These values must be taken with caution by engineers, inasmuch as they are largely due to the "mass effect" in tensile testing. The close relationship between size of the sample and high tensile strength is shown by the following results:

Size of Sample, Dia., In.	*Approx. Tensile Strength, Psi.*
0.00040	230,000
0.00035	250,000
0.00020	325,000
0.00010	425,000

The tensile strength of glass in sizes approximating the standard sample for the determination upon metals has not been satisfactorily established. Glass is highly notch sensitive, and slight surface imperfections or irregularities exercise an effect upon results entirely out of proportion to their physical magnitude. The conditions surrounding the preparation of the sample cause such variations in the results that the results are never reproducible. Tensile strength is ordinarily considered to be several thousand lb. per sq. in.

While the very high tensile results have been obtained with samples of microscopic diameter, there is no question about the high strength of cloth woven of glass fibers. Here again, results are dependent upon

weave of cloth, thread count, etc., so that comparable results are difficult to obtain. It can safely be said, however, that fabrics of glass fibers are very strong, and very durable in applications in which repeated flexing does not occur.

A major use of glass textile fibers at present is as an electrical insulator. Electric motors and similar electrical equipment are limited in ratings to the temperature at which the insulation will fail. Use of inorganic insulations, such as glass fibers or asbestos, made the varnish the first ingredient to fail. Development of silicone varnishes, in combination with glass fiber windings, promises to raise the temperature at which failure of insulation will occur to such a level that the lubricant will become the limiting factor.

Glass fiber yarns, woven sleeving, and other textiles of glass have become a standard insulation for motors to be subjected to high temperatures, or those for which weight limitations require operation at what would be overload under Class A (organic insulation) specifications. Transformers and other electrical equipment have likewise been adapted to higher-temperature operation by using this noncombustible insulator.

Thermal insulation, both for elevated temperatures and for refrigeration, is a large-scale application. Trains and busses, ships, planes, and homes have adopted glass insulating wool, supplied in batts, blankets, boards or sheets. Preformed boards have shown reductions in installation costs when used for such items as domestic heated equipment, industrial boilers, breeching, or heated tanks. Another type of preformed board, enclosed with asphalt, is preferred for low-temperature refrigerated spaces such as cold storage lockers, and commercial refrigerators. A grade compressed to a density of 9 lb. per cu. ft. is self-supporting in partitions.

Important as Laminating Material

Glass fabric has become an important laminating material for plastics. In combination with the phenolic and other thermosetting resins, its heat resistance and high strength make a lightweight, durable, high strength composite. Molded parts have found wide application in the aircraft industry, where high strength and light weight are worth premium prices. It has been used for defroster ducts, for tail surfaces, and for many other structural parts of aircraft. When used as a facing for lightweight core material, a sandwich composition can be made of great strength and rigidity, but of very low weight. A sandwich material of this sort is popular as a flooring in commercial planes.

Low pressure laminating opened a new field in plastics, making possible the molding of pieces of so large a size that no press could have been found to make them by high pressure methods. Boats have been molded in one piece by low pressure or contact methods, with glass fiber cloth or mat as the reinforcing material.

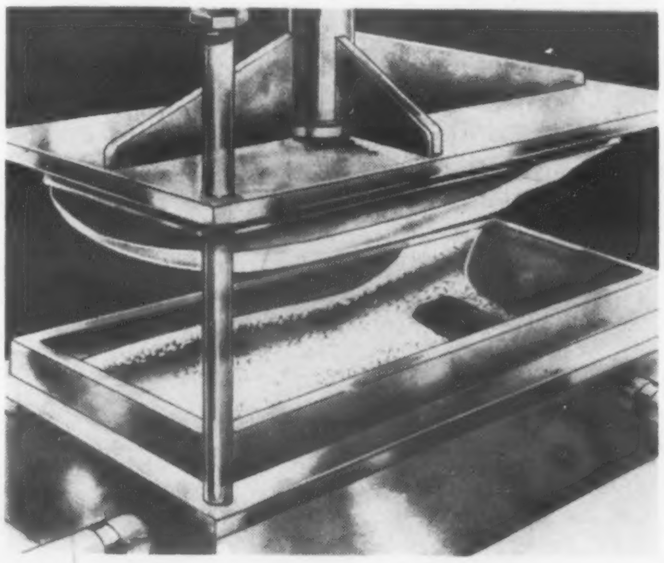
Ventilating and air conditioning have found relatively coarse glass fibers, lightly bonded with a resin and faced with a metal grille, to be an excellent filter medium. Use of dust-catching adhesive with the fibers increases their efficiency.

Fabrics of glass fibers have found important uses for themselves, without any helping material. While use of colored glass to make colored fabrics has not been successful, due to the faintness of the colors so obtained, the finished cloth can be surface dyed to brilliant colors. Colored sleeving is used industrially for identification. Fire-safe draperies and hangings for public buildings have proved popular, especially after several disastrous fires called attention to the hazard of combustible drapery.

Cloths of glass fiber, when coated with neoprene or with vinyl resins, have been used for gaskets and packings, diaphragms, high temperature conveyor belting, etc. Coated with bituminous paints, glass mat has served as a wrapping for buried pipe. Lamp shades, indestructible lamp wicking, and nonburnable ironing board covers have been made with glass fabrics.

Glass cloth, faced with mica, has been used for electrical insulation. A recent development has been production of super-fine glass fibers. Formed as batts loosely compacted with a binder, these have been used to replace kapok in lifejackets. Pillows stuffed with bulked fibers have been used by allergy sufferers. The super-fine fibers are used also as clothing interliners, and in thermal and acoustical insulating blankets for aircraft.

Glass fibers have been commercially available to civilian production for only about three years before the war, and about a year since. It can be confidently predicted that, when engineers have had time to consider the properties of glass fibers in relation to a going civilian production and its problems of material selection, many more uses for this valuable class of materials will be found.



In this drawing is illustrated a step in the plunger and preform process to make an automobile top. Lightly bonded short length glass fibers are in the steam-heated metal mold. After the resin has been poured on the preform the rubber plug will be lowered on it under pressure of from 40 to 100 psi.

Three drawn parts of the oil separator assembly. They are (left to right) the combined spacer and section, the inner shell, and the outside container.

Deep Drawn Magnesium Parts Save Weight

by R. G. GILLESPIE, *Brooks & Perkins, Detroit, Mich.*

THE AIRCRAFT INDUSTRY, always keenly weight-conscious, has been appreciative of the savings in weight possible through the use of magnesium alloys. With the steadily advancing knowledge of the techniques of working this lightest of all structural metals, more and more aircraft accessories are being adapted for production in these alloys. Magnesium, difficult to form at room temperatures, can be shaped with relative ease at temperatures within its plastic range, and these forming operations can be performed on ordinary presses with a few modifications of the usual set-up.

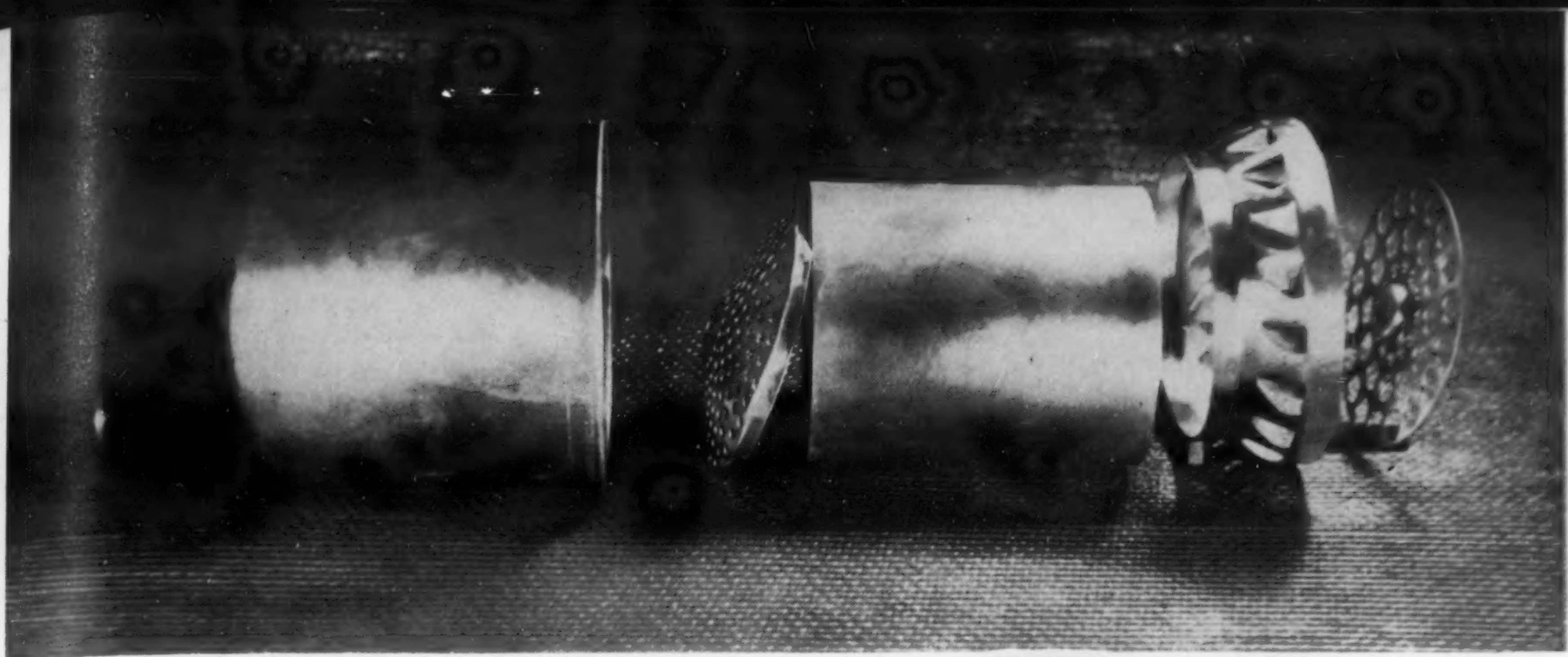
To take advantage of the use of magnesium, one rather complicated assembly was redesigned to permit deep drawing which eliminated other operations.

The deep drawing of magnesium in moderately heavy gages is still a matter challenging the skill of the engineer and designer. While such operations are being accomplished in many pressworking shops, close attention to details of technique is necessary to success with low scrap loss.

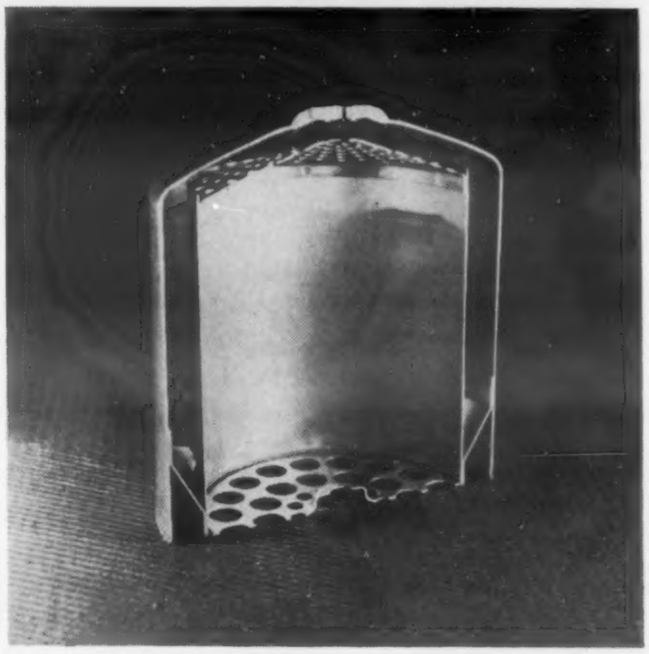
An oil filter, part of an aircraft de-icing system by Eclipse-Pioneer Div., Bendix Aviation Corp., was being produced in aluminum sheet, with several of the more difficult parts made by spinning. The desire for a weight saving, combined with the possibility of lower costs by rapid press forming, led to attempts to redesign the part for fabrication from magnesium, and by deep drawing.

As the outside container for the filter is 8-3/16 in. in dia., and a 10-in. draw would be required in 0.072-in. metal, close attention to details of press operation was required. An inner shell, 6⅝ in. in dia., also required a 10-in. draw, but the lighter gage metal, 0.051 in., would help to ease the problem.

Manufacture of the filter was undertaken by Brooks & Perkins, Detroit. MA alloy was used



Exploded view of parts, all of which are pressformed, of the aircraft oil separator.



A cross-sectional view of the oil separator.

throughout. In addition to the inner and the outer shells, there was required a spacer, having vanes opening slantwise from its periphery; a perforated inner section, to retain the filter medium at the bottom of the assembly; and a top retainer, also perforated, to hold the medium in place from the top. The perforated inner section is attached to the inner shell, and both are held in position by the spacer. A through-bolt, passing through the top retainer, the axis of the filter body, and the bottom of the outside container, completes the assembly.

To reduce die costs, number of operations, and to simplify the operation in general, it was decided to make the spacer and perforated inner section in one piece, and to separate them later by a cut-off operation on a lathe. The outlines of the two parts to be formed provided natural draft over most of the combined drawing, and made for relatively simple presswork.

The outside container, 8-3/16 in. outside dia., is made in one draw. Blanks are heated in an oven to 625 F, and an attempt is made to hold the material as closely to this temperature as possible during the entire run. The dies are heated by gas burners, located in this case on the die holddown ring. Die temperatures are checked at the beginning of each run, and the female parts of the die are held at sheet temperature. Male parts are run at a little below sheet temperature. A galvano-pyrometer is used to determine die temperatures at the beginning of the run, and the gas burners are so adjusted as to maintain the requisite degree of heat during ordinary operating procedure.

In this one press operation 12 stiffening ribs are formed on the bottom of the container, and the hole for the through-bolt is punched. A narrow seating flange at the top of the container is also formed. As this flange must be very flat and even surfaced to permit an airtight seal in the final installation, a restriking operation is performed on the flange.

A reinforcing piece, with a drilled hole, is later welded onto the bottom of the container to permit threading for the through-bolt. Heliarc welding is used to attach the relatively heavy perforated disk of magnesium to the light container, and the hole punched through the bottom of the container in the drawing operation is used to locate the disk.

Forming of the outside container is completed by

trimming off the top excess on a lathe. The finished piece is 9-3/16 in. deep.

Ten-Inch Draw in One Operation

The inner shell, also drawn to a 10-in. depth in one operation, is formed as a can, and the bottom is later cut off and top excess removed to achieve the required open cylinder. The press operation is carried out as for the heavier outside container. Trimming operations are done on a lathe.

The piece from which are cut the spacer and the perforated inner section is formed in one draw, and is slightly more than 6 in. deep as drawn. The required portions of the combination piece are cut out on a lathe, and further processed on small presses. Holes are punched in the inner dish-shaped section. To simplify the die work, the perforations are made in six successive groups, using the holes already punched to index for the following group, and so dealing with a sector of the dish that may be handled like a flat surface. After perforating, this inner section is spotwelded to the inner shell, over which it telescopes for a distance of ⅜ in.

The spacer, also trimmed from the combination piece, requires the punching of 18 fins on its slanted circumference. These fins are cut through one at a time, and each is given the outward slant necessary to effect a slight louvering. The conical nature of the surface upon which the fins are cut makes this a simple press operation.

The case for the filter is completed with the top retainer, a flat perforated disk of magnesium sheet through which the through-bolt passes, and which serves to hold the filter medium in the inner shell. Its fabrication consists of one operation involving simple blanking and perforating and the formation of a raised boss.

All parts are chromate treated for protection, and as a primer for the final finishing in the case of the outside container. The external surfaces of the outside container are given a baked enamel finish to complete the operations upon the filter case.

The filter serves as a regulating-unloading valve and oil separator for controlling and filtering the air pressure supply of an airplane de-icing system. A filter element is installed in the magnesium case to complete the device, which is designed to handle 20 to 40 cu. ft. per min. of air for a minimum of 100 hr. of operation, equivalent to about 1000 hr. of flying. When made of aluminum spinnings the case weighed 3½ lb. The redesign in magnesium was estimated to weigh 2½ lb., and actual weight of the completed cases has been found to be 2 oz. less. The total weight saving was, therefore, 18 oz. in 3½ lb.

Other Magnesium Products

Several other items, recently produced in magnesium, make dramatic weight savings by adopting the light metal. A 16-ft. canoe, full size in every respect, has been produced with a weight of slightly under 55 lb. Sportsmen have appreciated the advantage of lighter weight as much as the aircraft industry, even though it is not a matter of dollars and cents as in that industry. A wheelbarrow of magnesium, weighing 12 lb., has also been well received. Both pieces are produced by Brooks & Perkins also.

The canoe and wheelbarrow are interesting examples of large-sized work done in magnesium alloys by press forming. Both applications presented greater difficulties than those encountered in the drawing of straight-sided square or rectangular boxes and cylinders. The sloping sides of the wheelbarrow pan are difficult to draw without wrinkling and it was found that the hold-down pressure required is quite high. The angle of slope of the pan is different for different sides, necessitating an unusual amount of experimental pressure adjustment during die try-out. The canoe skin design is quite irregular and also required a large amount of experimental work on hold down pressure and on proper blank development.

For the canoe, MA alloy is used in an 0.051-in. thickness for the skin. Four pieces, each 8 ft. long, are drawn in a hydraulic press of 750 tons capacity. Temperature of the sheet is held at about 625 F, and the dies are heated to the same temperature at the start of the run. Nickel-iron dies are used.

The nickel iron dies are quite large, and, when heated, a great deal of both growth and normal thermal expansion was encountered. Unfortunately these dies were not stress relieved before being put into service, and much of the difficulty encountered may have been due to this fact. In the future such large, irregular cast dies will be heated at not over 200 F per hr. to a minimum of 900 F, and preferably to 1000, and held for 1 hr. per in. of section, then cooled at not more than 100 F per hr. to room temperature. This procedure was recommended in a paper presented by J. S. Vanick at the 1946 Convention of the American Foundrymen's Association. Engineers at Brooks & Perkins are now inclined to think that such treatment would obviate the effects of further relief of casting stresses at the temperatures and stresses involved in operation, and reduce the likelihood of significant dimensional changes in service.

After drawing, the pieces forming the skin of the canoe are trimmed on a band saw. Two sections are then welded together endwise to form a side of the canoe, using heliarc welding. The sides are joined, right and left, by riveting to a keel strip, which is an extruded magnesium alloy form. Extruded forms are also riveted into place to produce the gunwales, along the upper edges of the two side sections. A stretch-formed section is riveted to either end of the skin, from keel to gunwale, to complete the assembly of the skin, and small castings are riveted into place to join these formed pieces with the ends of the gunwale.

The structure is stiffened by thwarts, of oval tubing, extending across the canoe from gunwale to gunwale, and attached to the canoe by small magnesium castings. Stiffening ribs are also used. They are formed from sheet metal, using the rubber mat method.

Small decks, fore and aft, provide a space for packing Sytrofoam, a foamed plastic material, which insures buoyancy in case the craft is overturned. Bulkheads at each deck protect the lightweight plastic.

Assembling a wheelbarrow, practically all parts of which are magnesium. The pan is drawn sheet of 0.072 in. thickness.

Seats complete the canoe, and for this purpose woven Saran filament, stretched on a hardwood frame, is used.

In the magnesium wheelbarrow, MA alloy is used for the pan, which is formed in one piece from 0.072-in.-thick stock. The alloy is held at about 650 F for the forming, and the dies at about the same temperature. After trimming, the pan is beaded around the upper edge, and the result is a full size piece of extreme lightness, but with ample strength and rigidity for the service intended.

Handles for the wheelbarrow are made of magnesium alloy tubing, bent to shape in special bending jigs. The tubing is preheated to about 525 F for the bending operation, and the mandrels of the jig are held at about 500 to 550 F during the run. The legs are made from extruded flat bar stock, ⅛-in. thick.

Assembly of the wheelbarrow is very simple. A right and a left leg are joined by means of a single rivet, and the legs, pan, and tubular handles are assembled by bolting with four bolts. The forward ends of the tubular handles are flattened, and holes are drilled through them for the axle bolt. The rubber tired wheel is held in place by the axle bolt, with washers and two magnesium tubular spacers to position it.

Although the rubber tired wheel adds to the weight of the barrow, the total weight of the completed piece has been reduced from an estimated 16 lb. to its present 12 lb. by use of magnesium alloys for practically the entire construction. The axle bolt, rubber tired wheel, and rivets and assembly bolts are the only significant exceptions.

In all of these articles fabrication by pressforming hot magnesium alloy, in sheet or other form, demonstrates that the lightness and other advantages of this material can now be offered in connection with the advantages of high production methods. When properly handled, the light metal can be deep drawn, bent, sheared, or otherwise fabricated with sufficient facility to make it a competitive material, and its particular advantage of weight saving will become the deciding factor for many applications in the transportation industries, or where portability is important.

Quality control can reduce the amount of inspection required on almost any product.

Installing a Quality Control Program

by NORBERT L. ENRICK

SOMETIME IN THE NOT TOO DISTANT FUTURE, American producers will find themselves confronted by the end of the seller's market, with buyers no longer beggars but choosers. Then the manufacturer who has made a timely installation of quality controls in his plant will have a competitive advantage.

The method of choice is statistical quality control, which was developed first in the Bell Telephone Laboratories and recommended as having "contributed in a notable way to important reductions in costs and to substantial improvements of quality . . . in the Bell System." By now it has proven its worth in many thousands of large and small plants.

The great variety of metalworking processes makes it impossible to outline quality control on each. However, it will be sufficient to give practical examples of a simplified method applicable to most metal products. From these, the intelligent reader should be able to draw all the information needed for his own product.

Modern quality control aims at both a reduction in inspection and an improvement of quality. It does this through systematic sampling inspection of product following all key processing operations. The advantages are threefold:

1. The sample shows up bad quality immediately. Thus, the source of defective work—be it machine, material or operator—becomes known immediately and can be corrected at once.
2. The sample also serves to segregate immediately bad lots from good lots. Only good lots are

Given here are the principles behind the establishment and operation of a quality control program that can be a useful guide in any metalworking plant.

Master Sampling Tables

Sample Size	Allowable Percent of Defectives									
	1		2		3		4		5	
	A	R	A	R	A	R	A	R	A	R
40	0	2	0	3	0	4	1	5	1	5
60	0	2	1	4	1	5	2	6	2	7
80	1	3	1	5	1	6	3	7	3	8
100	1	3	2	5	2	6	4	8	5	9
120	2	3	4	5	5	6	7	8	8	9

Sample Size	Allowable Percent of Defectives									
	6		7		8		9		10	
	A	R	A	R	A	R	A	R	A	R
40	1	6	1	7	2	8	2	8	2	9
60	3	8	3	9	4	10	5	11	5	11
80	5	10	5	11	6	12	7	13	8	14
100	6	11	7	13	8	14	9	16	10	17
120	10	11	12	13	13	14	15	16	16	17

Note: A = Acceptance No. R = Rejection No.

Lots should consist of at least 600 pieces, and at most 3,000 pieces.

Fig. 1 — Master sampling tables are the keystones around which quality control programs are built.

passed and reach the final assembly. Bad lots are detailed for screening, repair, salvage, etc.

3. The above two factors combined should eliminate the need for costly and time-consuming 100% inspection (inspection of every piece) before final assembly and shipment.

The Pilot Installation

To start quality control in your plant, it is best to begin in one department and to expand it gradually. For a comparatively simple example, let us assume that you are manufacturing flatware knives and that you start quality control in the press department.

Workers place their product into skids of boxes, each holding approximately 1,000. Experience shows that the key operation to be inspected is the forming of stainless steel knife handles on a knuckle press, since this operation is chiefly responsible for defective work.

Because of the skill required in positioning the handles under the die (to avoid mis-forming and burrs in excess of 1/8 in.), up to 2% defective work is not considered abnormal. We therefore call 2% defectives *in this case* the Allowable Percent Defective. (Other items or operations may require different percentages.) If you want to make practically sure that not more than 2% defective handles go out of this department, you must tell your inspector exactly:

How many sample pieces to inspect.
When to pass a lot.
When to reject a lot.

This information cannot be obtained through guess work or rule of thumb. However, it can readily be taken from statistical tables.

Without use of such tables, sampling inspection is a haphazard business, because sampling is subject to a greater margin of error than usually expected. By chance, the inspector may inspect only good sample pieces from a bad lot, or vice versa, all of which leads to too many wrong decisions: too many bad lots slip through, or else too many good lots are rejected.

It is here where the statistics of mathematical probability helps the inspector: by furnishing him with a practical sampling plan that results in a *minimum amount of inspection for a maximum of protection against sampling errors.* Without this, there will usually be either too much inspection or else not enough.

To install a simplified quality control program, you need know nothing about mathematics, but merely refer to the Master Sampling Tables (Fig. 1), which furnish ready-made sampling plans into which all the mathematics has been incorporated in advance.

Using the Sampling Plan

In our example, the Allowable Percent Defective for knife handles formed on a knuckle press was fixed at 2%. By referring to the 2% column in the Master Table, the following individual sampling plan is extracted and furnished to the inspector:

Sample Size *(Cumulative)*	Acceptance No. *(Cumulative)*	Rejection No. *(Cumulative)*
40	0	3
60	1	4
80	1	5
100	2	5
120	4	5

This plan supplies the inspector with sets of three all-important numbers:

1. *Sample Size*—The number of articles to be examined out of each lot. These must be drawn at random from different parts of the lot.

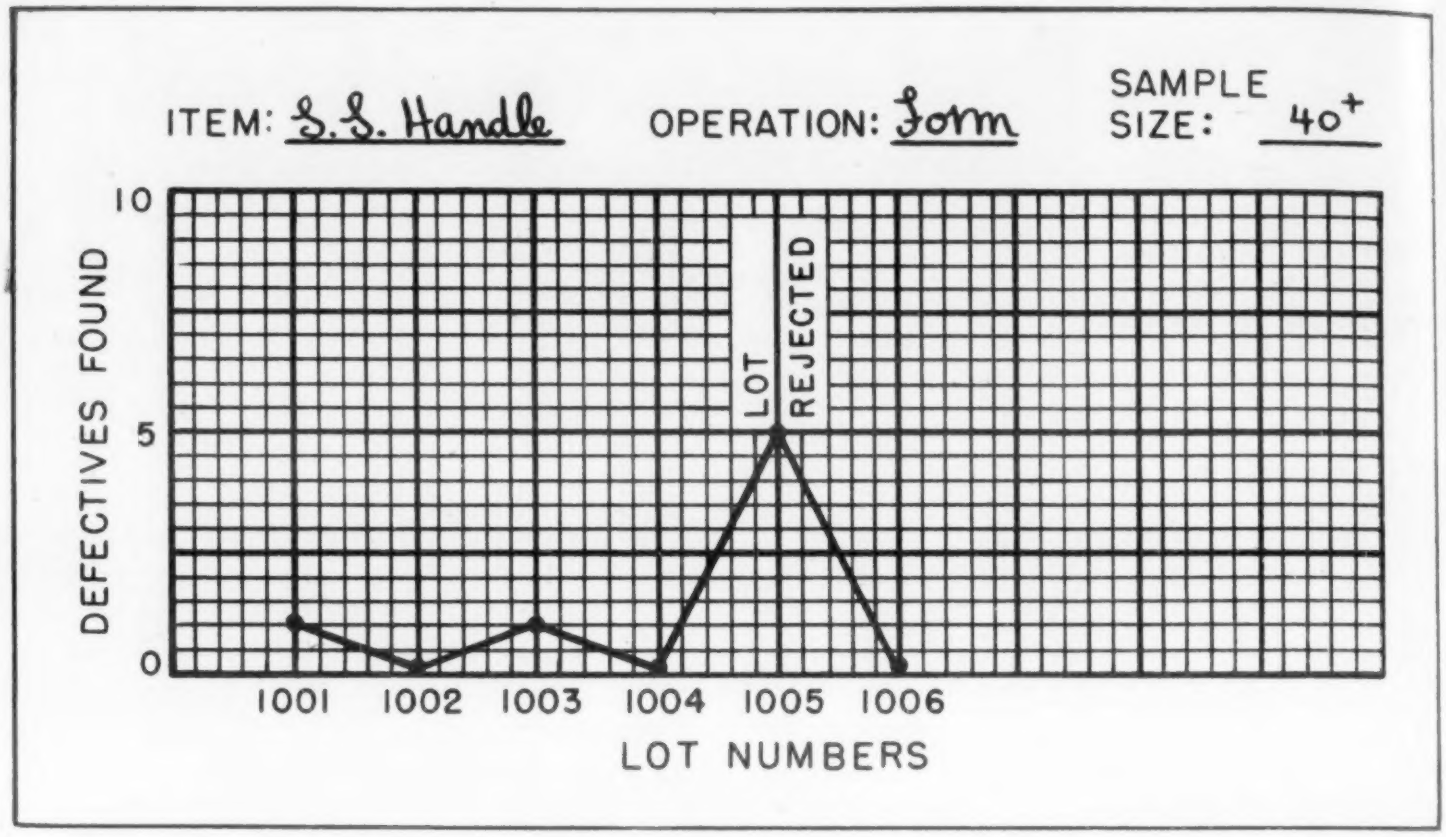


Fig. 2—Daily records should be kept of parts inspected and should show why any lots required rejection.

2. *Acceptance No.*—If defectives up to this number are found in the *sample,* the *lot* will still be accepted (passed).
3. *Rejection No.*—If this number or more defectives are found in the *sample,* the *lot* is rejected (and sent to repair, screening, salvage, etc.)

The distinctive feature about this table is the gap between the *acceptance* and *rejection numbers.* This gap forms an area of indecision, meaning that if the number of defectives found falls into this gap, an additional sample must be taken. Additional evidence is required in the form of more samples.

For example, if the inspector has found *one* defective in his first sample of 40 pieces, he can neither accept nor reject the lot, since the Acceptance Number is 0 and the Rejection Number 3. So, the inspector must take another sample of 20, bringing his total sample size to 60 (40 plus 20). Again the inspector will compare the total number of defectives found up to this point to determine whether to accept or reject the lot or to continue sampling. This process may go until the highest sample size is reached, 120, at which point the gap between the Acceptance and Rejection numbers disappears and the problem of acceptability is finally solved.

This type of sampling—called sequential—has a distinct advantage: It will generally permit very good lots to be accepted and very bad lots to be rejected after the first or second successive sample. Only lots of in-between quality will, on the average, require more inspection. Thus, we make sure that an *absolute minimum* of inspection is done.

Inspection Records

It is desirable that the inspector keep a record of the many hundreds of pieces inspected daily. An example of such a record is given in Fig. 2.

From this record, it will be noted that one lot, No. 1005, was rejected for excessive burrs. On the bottom, the reason for rejection is indicated: The die had shifted and consequently was not mitering properly. This left excessive burrs on the handle. Inspection had rejected the lot and notified the foreman. He, in turn, had checked into the trouble and adjusted the set-up. The bad lot itself was "screened." That is, every piece was inspected and those with excessive burrs held aside for a special de-burring operation.

Inspection records tell, at a glance, what happened all day. Properly summarized, they give valuable information to the engineering department in knowing where to concentrate on machinery improvements. At the same time, figures on percent-defective and allowable percentages can form the basis for quality-quantity bonus systems, cost controls, etc.

In place of inspection records, many organizations prefer control charts (Fig. 3). These have the advantage of being quicker to understand, but show less detail.

Sampling vs. 100% Inspection

Introduction of scientific sampling is often opposed in favor of old fashioned 100% inspection because "only if you inspect every piece can you guarantee perfect product." However, because of the monotony of this procedure and the inevitable fatigue, the in-

LOT-BY-LOT INSPECTION RECORD

1. ITEM: S. S. Knife Handles

2. LAST OPERATION: Forming on Knuckle Press

3. OPERATOR: K. Hall

4. DATE OF INSPECTION 1946	10/1	10/1	10/2	10/2	10/2	10/3
5. LOT NUMBER	1001	1002	1003	1004	1005	1006
6. LOT SIZE (NO. OF GROSS IN LOT)	1,100	2,000	1,500	900	1,000	1,000
7. ORIGINAL OR RESUBMITTED LOT (CHECK ONE)	✓ ORIG. / RESUB.	✓ ORIG. / RESUB.	✓ ORIG. / RESUB.	✓ ORIG. / RESUB.	✓ ORIG. / RESUB.	✓ ORIG. / RESUB.

8. SAMPLING TABLE			9. MAJOR DEFECTIVES					
SAMPLE SIZE	ACC. NO.	REJ. NO.	NUMBER	NUMBER	NUMBER	NUMBER	NUMBER	NUMBER
40	0	3	1	0 ✓	1	0 ✓	2	0 ✓
60	1	4	1 ✓		1 ✓		2	
80	1	5					4	
100	2	5					5 ✗	
120	4	5						
CHECK NO.								

10. TYPES OF DEFECTS FOUND	11. DEFECTS NUMBER	NUMBER	NUMBER	NUMBER	NUMBER	NUMBER
Excess Burrs (more than 1/8")	1				~~||||~~	
Deep pit mark on handle			1			

12. LOT ACCEPTED OR LOT REJECTED (CHECK ONE)	✓ ACC. / REJ.	✓ ACC. / REJ.	✓ ACC. / REJ.	✓ ACC. / REJ.	ACC. / ✗ REJ.	✓ ACC. / REJ.

13. INSPECTOR'S SIGNATURE: Ray Jector

Fig. 3—Some quality control programs prefer control charts such as this rather than other types of records. This chart shows much the same information as the report in Fig. 2.

spector can never hope to catch all defectives. He always misses some, usually more than anticipated.

If a guarantee of perfect product is needed, you will probably have to resort to 200% inspection, unless some mechanical inspection machinery can be used.

The Master Sampling Table in this article contains various sampling plans, ranging from an Allowable Percent Defectives of one up to ten. This should provide for most needs of the average plant.

Do sampling plans eliminate all chance errors of sampling? Obviously, no sampling plan can do that, since we do not inspect all pieces. However, sampling plans minimize the risk of error.

When the sampling plans given here are used, it will occasionally happen that a bad lot slips through. However, in the long run these sampling plans work out so that the average proportion of defective work passed will never exceed the allowable percentage. This is true provided that each individual article inspected is examined or tested properly and all rejected lots are repaired before being passed.

So much for the risk of letting bad work slip through. How about the risk of erroneously rejecting good lots? This chance, too, is ever present. It varies with the quality of the inspection lots and reaches a maximum of 15% as the lots move close to the borderline of rejection.

Under most types of mass production, these risks have been widely found both practical and economical. In those special cases where different risks are desired, special tables may be needed.

What has been presented herein is a skeleton procedure, which, however, should be a good working tool for most purposes. It is, of course, not generally applicable to control such variables as tensile strength, weight of coatings, temper, close tolerance dimensions, etc. For them, more refined statistical tools have been perfected which cannot be presented in ready made tables.

However, for the average plant the above outlined general procedures are sufficient at least to make a start. They have proven their worth after having been installed successfully at more than 3,000 plants during the war.

The new zinc-base finish for steel results in the chromium-like appearance of this refrigerator shelf.

Shortage of tin led to development of a finishing method which results in a hard, long wearing surface that gives the appearance of being chromium plated.

A New Zinc-Base Finish for Steel Parts

by J. A. WILLIAMS, *United Chromium, Inc.*

A NEW ZINC-BASE FINISH for metal parts, which is being widely applied on refrigerator shelves, provides greater corrosion resistance than the formerly used tin finishes. The new finish was developed as an answer to the shortage of tin. Tin was the most widely used finish prior to the war and was generally applied by hot dipping. The finish has a bright metallic appearance somewhat similar to that of chromium plating.

Three distinct operations are required to achieve the zinc-base finish which is harder, and which provides greater protection against rusting than the pre-

(Left) As the process is used by Metal Process Corp., Detroit, the metal parts are first plated in a semi-automatic zinc plating tank. (Center) In this plant the Anozinc treatment is handled in a manually operated tank. (Right) As in other finishing processes, prior cleaning is important. Here refrigerator shelves are being removed from an alkali cleaner prior to zinc plating.

viously used tin finish. First, the steel refrigerator parts are zinc plated to a thickness of from 0.0003 to 0.0005 in. Next, the zinc plated parts are treated in Anozinc Clear to form a corrosion-resistant conversion coating. Finally, the shelves or other steel parts are coated with a clear baking synthetic to provide increased abrasion resistance.

Many manufacturers using the process now indicate that they will continue the method even when the need for conserving tin no longer exists.

One big advantage claimed for the zinc-base finish is that if and when a small area is worn through, electrolytic action between the zinc and steel prevents the steel from rusting. When soft tin was used on such shelves and was worn through to the steel, rusting was accelerated due to the opposite electrolytic action taking place.

While trying to find a satisfactory finish, the refrigerator manufacturers investigated at least 100 different metallic and synthetic coatings. The two most important properties required of a finish were that it should possess excellent corrosion resistance and that it should also have an attractive metallic appearance. None of the hundred finishes tested passed both of these requirements. Several metals which might have provided the required corrosion resistance had to be eliminated from consideration because of their toxicity. Plating copper, nickel and chromium over the steel shelves proved unsatisfactory because no feasible thickness of plate provided satisfactory corrosion resistance at the welded joints where the light cross wires are welded to the heavier wires which form the frame of the shelf. Many lacquers and synthetic coatings were tested, but none of them were acceptable either because of poor corrosion resistance or because the finish did not have the desired metallic luster.

In early 1945, engineers of United Chromium, Inc. suggested that a satisfactory finish could be produced by zinc plating the shelves, then forming a clear conversion coating to retard the formation of white zinc corrosion products, and then applying a durable baking synthetic. For test purposes, several shelves were zinc plated, then treated in a United Chromium Yellow Anozinc bath. The yellow coating was then leached and sealed to provide a clear corrosion-resisting conversion coating. Then a specially formulated synthetic, Unichrome Lacquer B-132, was applied.

Months of testing by the refrigerator manufacturers proved that this finish would stand up under actual service conditions. The conversion coatings produced in the Anozinc bath exhibited outstanding resistance to corrosive conditions, humidity, wear and food contact, and also reproduced the luster of the underlving zinc. During the Summer of 1945, Anozinc Clear was adopted as the standard finish for steel refrigerator shelves by Norge, Nash-Kelvinator, Gibson, Philco, Coolerator and others. Although this was the first widespread application of "Anozinc" Clear, it was not an entirely new treatment. During the war, "Anozinc," both Black and Yellow, had been developed while searching for a protective coating for steel cartridge cases. "Anozinc" Clear was an outgrowth of these "Anozinc" treatments but was set aside temporarily because it was a decorative finish.

A proprietary chromate-type bath is the basis for the electrolytic formation of the zinc conversion coating. The bath is easily controlled and the process has proved very economical. The long life and low maintenance cost of the "Anozinc" bath has been established by the records of many fabricators who have found it economical no matter whether it is used in manual, semi-automatic, or full automatic operations.

The finish for these steel refrigerator shelves is produced as outlined below:

Zinc Plating

The zinc plating is done in an alkaline bath at a temperature of from 75 to 85 F and a current density range of 5 to 50 amp. per sq. ft. From 0.0003 to 0.0005 in. of zinc is deposited, depending on the manufacturer's specification. As the final appearance of the shelf depends upon the luster of the underlying zinc, care is taken to produce a bright plate.

Anozinc Clear Treatment

1. Rinse the zinc plated shelf in cold and then hot water.
2. Anodize in Yellow "Anozinc" bath at 5 to 20 amp. per sq. ft. for from 1 to 5 min.
3. Rinse in cold water.
4. Soak in boiling hot Sealing Bath for 10 to 15 min. In this bath, the yellow color of the coating disappears, leaving the surface with a clear, metallic appearance.
5. Rinse in cold water.
6. Rinse in hot water and dry.

Application of Synthetic Coating

The dried shelves are dip-coated with one coat of clear synthetic lacquer and baked at 250 F for 20 min. The coating most commonly used is United Chromium's Unichrome Lacquer B-132, which was developed especially as a coating for Anozinc Clear and other conversion-type coatings. What makes this particular coating especially good for this application is its excellent resistance to abrasion, organic acids, fats, soap and moisture, and its good dipping characteristics.

The general acceptance of Anozinc baths by refrigerator manufacturers is evidenced by the fact that at least 75% of the refrigerator shelves processed in the last year have been finished with the Anozinc treatment. It must not be concluded, however, that the application of Anozinc is confined to refrigerator shelves. For some time, the black Anozinc finish has been used as a protective coating by aircraft propeller manufacturers on zinc plated steel propeller blades, while the yellow Anozinc coating has been used very successfully on zinc plated wire screen cloth. It now appears that many more applications for conversion coatings will make their appearance in the near future.

MATERIALS & METHODS MANUAL 24

This is another in a series of Manuals on engineering materials and processing methods, published at periodic intervals as special sections in Materials & Methods. Each of them is intended to be a compressed handbook on its particular subject and to be packed with useful reference data on the characteristics of certain materials or metal forms or with essential principles, best procedures and operating data for performing specific metalworking processes.

Salt Baths for Metals

by Edwin Laird Cady

With salts now available for nearly any metal heating purpose, salt baths are rapidly gaining in favor in the metal fabricating industry. Among other things, salt baths are now used for case hardening, through-hardening, quenching and descaling ferrous metals; annealing nonferrous metals; soldering and brazing, and heating metals for forming. In choosing such treatments, the most important single consideration is that of the type of salt to use. Presented in this manual is a comprehensive section on salts and their selection, as well as discussions of the various current uses for salt baths.

Contents

Introduction . . . . Page 100
Salts and Their Selection . . . . Page 101
Liquid Bath Case Hardening . . . . Page 106
Types of Liquid Bath Case Hardening . . . Page 108
Through-Hardening, Tempering, Etc. . . . . Page 110
Brazing and Soldering . . . . Page 114
Descaling . . . . Page 114

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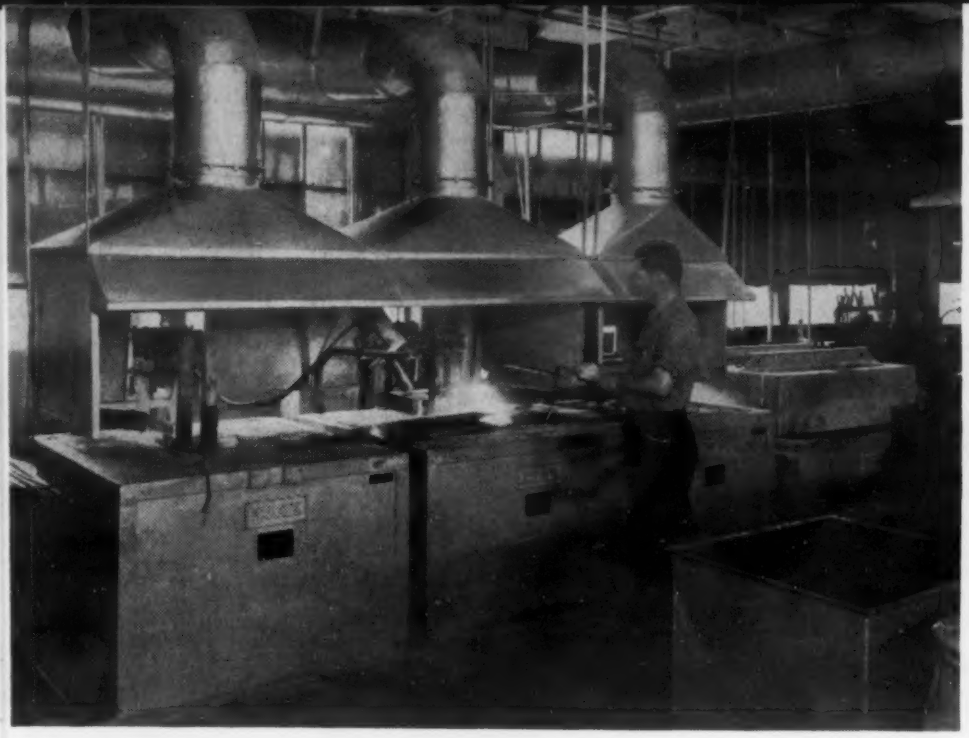
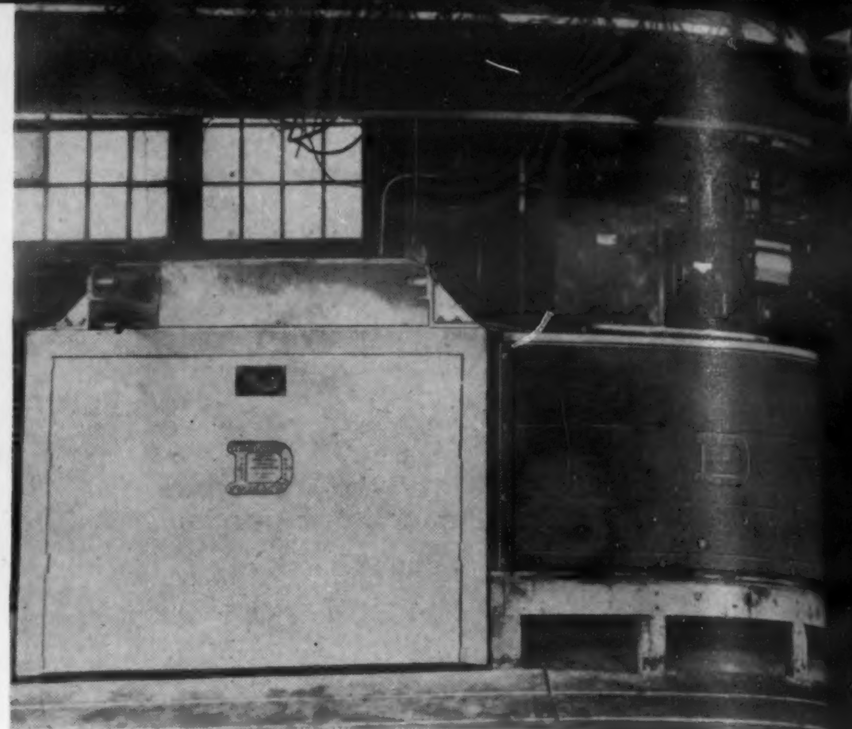




Introduction

A salt bath, as dealt with here, consists of a tank, vat or "pot" filled with salts or with mixtures of salts and chemicals, operated at temperatures above the melting point of the mixtures, and used for the processing of various metals and their alloys. Chemical salts of barium, sodium, chlorine and others constitute the great bulk of operating materials used in salt baths, but at the rate that new developments are coming it is not impossible that some of the "salt baths" of the future will consist of "chemicals" which include no salts whatever.

Molten salts also are used in heat exchangers, mostly in completely closed or pipe systems but in some open systems as well, in chemical plants and other process industries, in restaurant cooking devices, and for the setting of plastics. (The plastics powder is placed in the mold and the mold immersed in the molten salt to bring it up to the setting temperature, after which it is withdrawn and the finished plastic item removed.) But these uses are of interest to the metalworker only in that they increase the sales volumes of salts and of salt heating equipment and therefore provide funds for research to improve salt bath techniques for metal working. The odd uses will not be discussed further in this manual.

Authorities, such as the makers of salts and of furnaces, generally estimate that there are 20,000 to 30,000 salt bath installations in use in metal fabricating plants. This means at least a salt bath in the tool room, and usually other salt baths in other departments, in practically every metalworking plant which employs 50 or more men, and plenty of salt baths in smaller plants. The smallest of these salt baths have pots no larger than water tumblers. The largest in actual operation undoubtedly are those of a battery used for the heat treatment of steel springs in the plant of the Standard Steel Spring Co. at Coraopolis, Pa. A single unit here includes one pot 221-in. long, 108 in. wide and 48 in. deep and holding 75,000 lb. of salt, unitized with another 150 in. long, 93 in. wide and 48 in. deep and holding 45,000 lb. of salt. But the smaller units scattered about the industrial districts consume by far the largest volume of salt and are of greatest interest to the salt makers and to most of the furnace makers.

Still larger units will begin operating in the immediate future. One of them, to be used for sodium hydride descaling of steel, will be 40 ft. long, 76 in. wide and 12 ft. deep and hold 300,000 lb., or 6 carloads, of salt.

The variety of uses which the average plant makes of salt baths is a different story. Here the salt makers and the equipment makers are offering far more opportunities than their customers are cashing.

One of the reasons for this slowness is that a great many of the best salt bath developments arrived during or immediately before the war and therefore were available only where badly needed for war production. The peacetime market has not had time to catch up with them.

Another reason was the development-stage habit of salt and equipment makers leap frogging each other. A salt bath consists of salt (or chemicals) plus equipment. First the furnace makers would have better equipment than the existing salts needed, then the salt makers would develop something which needed more than the furnaces could give it, then both would be ahead of the control equipment makers. But as the situation stands right now, the furnace, pot and control equipment makers are ready for anything the salt makers can bring them, and the salt makers are ready with plenty of new developments to take advantage of everything the equipment men can give them. Let the raw materials markets, especially the chemicals and ceramics markets, loosen up a bit and so many extensions of existing salt bath adaptabilities will be announced that metal fabricators may take years to begin using them all. And in the meantime the salt baths have become so efficient and versatile that many a plant is basing the most drastic and dramatic process changes in its history upon what the new salt baths can do for it.

Specific applications including some of the newer and little known ones will be discussed in various parts of this manual. A general statement could be made that there is no type of metal heating operation requiring temperatures of less than 2400 F which has not been, or at least is not expected to be, performed in salt baths, and that there is no reason why bath materials capable of still higher temperatures should not soon appear on the market. Melt-

(Left) A battery of Ajax immersed electrode type furnaces for hardening high speed steel tools, including preheat, high heat, quench and draw furnaces. (Center) These Dempsey salt baths are used in heat treating stainless steel cutlery blades. A moving cover over the tank prevents excessive heat losses. (Right) This small Holden electrode furnace with ceramic pot is used to heat treat Bourdon tubes for gages at 1850 F.

ing operations are rare but have been performed on some low temperature melting alloys. No actual example of welding in a salt bath was seen while preparing for this manual, but several are said to be in the experimental stage. An indicative list of the most common salt bath operations is:

Annealing, various metals and alloys:
- Cyclic annealing

Cleaning, various metals and alloys:
- Descaling
- Removal of
  - Rubber and other organic materials from molds and parts
  - Enamel
  - Sand from castings

Heat Treating, nonferrous metals

Heat Treating, steels and ferrous alloys:
- Carburizing
- Coloring
- Cyaniding
- Interrupted Quenching:
  - Austempering
  - Martempering
  - Spherodizing
  - Combinations of these
- Quenching
- Tempering

Joining:
- Brass Brazing
- Copper Brazing
- Expansion Fitting
- Silver Soldering
- Soft Soldering

Heating for:
- Drawing
- Extruding
- Forging
- Forming
- Riveting
- Rolling
- Spinning

Preheating for Higher Temperature Heating

There are good reasons why so many salt baths are in use and are profitable for so many different types of operations, and equally good reasons why salt baths are somewhat slow to take hold in many plants for many purposes. Reasons for using them include:
- High speed operation
- Certainty of results since the operations are controllable
- Reduced floor space for same output
- Elimination of other operations
- Reduced fuel and power bills for same output
- Little need for high skills in operators
- Performance of operations which, by other methods, either would be too high in cost or could not be performed at all.
- Materials handling and other mechanization advantages.

Reasons for not using more salt baths include:
- Hazards which do not exist with other processes
- Some materials and equipments have been unavailable
- Unfamiliarity with operations and advantages
- Habituated to other methods, benefits of making the change not worth the cost of acquiring the "know how"
- Sometimes add to number of operations for same result
- Difficulties of tooling, materials handling, mechanization
- Public relations because of fumes, wastes disposal
- Patents and licensing situations.

Salts and Their Selection

The basic elements of a salt bath are the salt (or chemicals mixture), the pot, the heating means or furnace, and the controls for temperature and sometimes for process time.

Of these four, and within narrow limits, the salt is the easiest to vary and adapt. The salt must be of a type suitable for its operating temperature and its function, but beyond that limitation it usually can be selected to fit the needs of all the other elements.

So far as the material of which it is made is concerned, the pot also is somewhat easy to adapt. In this respect the salt could be compared to a cutting oil and the pot to the basic machine tooling. And like cutting oil and tooling, the salt and the pot must be selected to get along with each other and to do the work.

The furnace or heating means may be fuel fired or may be electric. There is no known means of generating and applying heat which cannot be used with salt baths. But although many types and constructions are highly flexible, it would be rare for one of them to be as completely adaptable as the salts.

Controls, of course, are controls. This is a short way of saying what every engineer knows, that some of them are highly flexible and some highly inflexible or single purpose. Depending upon the purpose of the salt bath and the amount of work being processed they may range from completely adaptable small pyrometers to highly intricate and coordinated electronic circuit recording controllers. The usefulness of the simple ones may be independent of the type of salt, the effectiveness of the complex ones may require close control of the salt analysis.

The actual heating of the parts in the salt is only one of a sequence of operations which comprise salt bath operation. Any of these operations may affect the type of salt selected. Bath operation may be crude and infrequent, or exact and continuous. Nevertheless, all of the operations count. They are, in the order of per-

formance but not necessarily of importance:

1. *Preparatory cleaning*

Parts to be immersed in salt baths should be clean. They positively must be free of materials which can cause explosions in the baths, as for example, parts to go into nitrate baths must be free of carbonaceous materials. Any dirt on the parts tends to contaminate the baths. However, there are cases of crude and infrequent operation in which little attention is paid to cleaning of parts. De-rubberizing operations often are performed with oil or other dirt in the rubber. If cleaning is not to be done then the baths must contain salts of such natures that the dirt will not set up hazards. Cleansing materials, if not fully removed from the parts (a factor that can be difficult to make sure of when the parts contain deep recesses or sharp undercuts), must be neither hazardous nor injurious when immersed in the baths, and this may mean careful selecting of salts as well as of cleansing materials.

2. *Preparatory drying*

Parts must be dry. They should not even bear the surface dew or moisture which cold metal can collect on a humid day. Salt baths are operated at temperatures above that at which water turns to steam. If the parts carry water only to the bath surface the result may be a slight spattering. But if entrapped water is carried below the bath surface the spattering can be highly dangerous. Heat is the easiest means of drying, and heat recirculated from the furnace or found immediately above the bath may be used. But the drying is a distinct operation and the necessity for it sometimes slows down the production rate at which a bath can be operated.

3. *Preparatory setting up of work*

Work sometimes can be "set up" by merely throwing it into wire baskets or metal ladles which then are immersed in the bath. But there are differences in the ways in which salts will perform for this, especially if the operation is cyaniding, carburizing or nitriding. Some salts will penetrate and do their work far deeper in a mass of small parts than will others (see "example of a change of salts" which appears elsewhere in this manual). Some salts have higher specific gravities than others and accordingly will better support masses of parts against distorting each other.

Parts may need to be individually wired for suspension in the bath. In this case little weight of metal is likely to be in the bath at one time, and the specific heat of the salt is less important than as if greater weight of metal were loaded at one time. This sometimes adds greatly to the flexibility of adapting the salt to other factors.

Parts may need to be held in special trays or forms or even in fixtures to prevent distortion. In brazing or soldering the setting-up and holding to prevent movement before the joining is complete can be life or death to the process. This can be expensive enough to mean economical defeat for the salt bath. If not handled correctly it provides chances for soils to get onto or into the parts and fixtures. It can mean sufficient weight of total load so the specific heat of the salt can make a serious difference in the ability of the bath to return to temperature after the cold load has reduced its temperature. The quicker that return the speedier the process. Salts of higher specific gravities can reduce some of these problems by giving greater support to the work, but the opportunities to take advantage of this seem to be very little capitalized by salt bath users.

4. *Immersing the work*

In the great majority of salt baths the work and its holding means are simply plunged beneath the surface of the bath. But in rapidly increasing numbers of installations mechanical handling devices are used and the work moves into and out of the bath with a constant timing and at a constant rate of speed.

This often means that the work moves parallel to the surface of the

SALTS FOR SALT BATH TREATMENTS

Salts as heating media for ferrous metals offer certain advantages over other media in that they generally prevent scaling, keep surface decarburization to a minimum, and, because of the uniform heating offered, prevent cracking and warping. They can be used where oil is not satisfactory because of its flammability; are easier to use than lead, in which work must be held down in the bath.

There are various salt compositions designed for special applications, but practically all salts can be classified according to the temperature ranges in which they are usable. These are the three broad temperature groups:

300 to 1200 F for	**Quenching carbon and alloy steels** **Tempering steels** **Bluing steels** **Age hardening aluminum alloys** **Annealing nonferrous metals** **Descaling steel parts**
1100 to 1800 F for	**Heating carbon and alloy steels for normalizing, annealing and hardening** **Carburizing** **Cyaniding** **Bright annealing of nonferrous metals** **Heating for spinning or forming** **Preheating** **Silver brazing**
1850 to 2350 F for	**Hardening high carbon-high chromium, or air-hardening steels** **Hardening high-speed steels** **Copper brazing** **Heat treating stainless steels**

The temperature ranges given cover all salts including those of the neutral type; case hardening and carburizing salts; and, tool nitriding salts.

bath after immersion. The liquidity of the bath at operating temperature then can make a difference in the fluid resistance of the salt to the movement of the work, and hence to the distortion of the work.

The container may need to be more of a channel than a pot, either long and narrow or else circular in shape, so the work will have sufficiently long exposure to the salt while being kept in constant although slow forward motion. This sometimes creates heat distribution problems for the furnace or other heater, problems that in some installations are best handled by making sure that the salt is sufficiently high in specific heat.

5. *Removing the work*

A thin film of salt adheres to the work removed from the bath. This film almost always is protective against oxidation of the hot work by the air, but in rare cases a special process salt may contain chemicals of such nature that they will combine with the air to promote corrosion and the immediate removal of the film is advisable.

The film is formed when the liquid salt which is raised with the work attempts to flow back into the bath. Some of the salt manages to drop back, the rest freezes upon contact with the cool air. On an uninterrupted work surface the amount of salt which clings depends upon the adhesiveness of the molten salt to the work and therefore the amount raised with the work, the liquidity of the salt at operating temperature and therefore the speed with which it will run off from the work before the freezing process can begin, and the closeness of the bath temperature to the freezing temperature of the salt and therefore the amount of heat loss and the time period necessary for this heat loss before freezing—the longer this time period the more the salt can flow back and the lighter the film. The heat emissivity of the work is higher for some metals than for others and will have its effect upon the time period during which the salt remains liquid and can flow. The specific heat of the salt also affects the rate at which the change from the molten or liquid state to the frozen one will take place, and therefore the time period during which the air-exposed salt can continue to flow.

When the work surface is interrupted, or there are deep recesses or under cuts, then the drag-out will be greater and the importance of the heaviness or thickness of the salt film also will be greater.

Large and increasing amounts of work go directly and while still hot from the baths to forging dies, drawing dies, extruding dies, rolling mills and other hot process equipment. The extent to which the adhering salt film damages these tools is unknown, or at least does not seem to have been completely enough measured so it can be evaluated. Likewise, no case of the salt being considered beneficial to the tools has been uncovered.

In practically all other cases the salt must be cleaned from the work. A heavy film entrapped in recesses can increase this problem.

6. *Cleaning Salts From Work*

Unless the work is to go directly to a hot fabricating process as described above, then it may be allowed to cool in the air, it may be plunged into oil or water either for quenching or for quick cooling, it may be routed to a second salt bath and perhaps from there to a third. At some point in its further processing the adhering salt film must be removed. The film may also need to be removed from the work holding devices and materials handling equipment before they can be reused.

Some salts are easy to remove and some are difficult. The worse the problems of deep recesses and undercuts the greater the value of easy removability. There are plenty of examples of salts which are higher in cost and lower in efficiency in the bath being used because they are easier to remove. Some of the ordinarily most desirable salts can be so difficult to remove from small holes and deep recesses as to be economically impossible for some work although they are used for other work in the same plant.

Salts which are water soluble and therefore easy to remove may be hygroscopic enough so that immediacy of cleaning is important. A few plants which changed to these reported that rust occurred at unexpected places on the parts long after the parts had been cleaned and rust-proofed, and that upon close inspection they found that with previous salts they never had been getting all of the salt out of deep recesses but that it never had done any damage there. Thus, a change to a different salt, even to one which ordinarily is very easily removable, can bring new problems of cleaning and has been known to increase the number of cleaning operations necessary.

The selection of a cleansing agent high in wetting-out abilities and forming no insoluble compounds with the salt, or at least no such compounds which will adhere to the work, can be helpful. Some salts which are advocated to be removable only by soft hot water are better removed by these agents. But there are instances in which a dilute acid dip to "kill" the alkalinity of the salt is considered necessary before the salt becomes completely removable. The study of cleansing agents by a high percentage of salt bath users has not been anywhere near so thorough as could be profitable.

When the parts are to be quenched directly into oil a salt which will not saponify or otherwise damage the oil should be selected. Some salts are partially but readily soluble in the oil, and this seems to increase the ease of cleaning without reducing the efficiency of the quench bath. The less soluble or nearly oil-insoluble ones usually sink to the bottom of the bath and there form a sludge which does no damage other than to need occasional removal.

When parts are to be transferred from one salt bath to another, as in salt bath quenching or tempering, care must be taken that the salts in the baths are compatible. Cyanide salts transferred to nitrate ones can cause explosions. Thre are other salts which if combined will greatly increase the cleaning problems.

The parts coming from the first bath may be cooled to a temperature which will not cause the cleansing medium to form steam, or if it be an organic solvent, to catch fire, then the parts may be cleaned and placed in the second bath. Obviously, this cleaning must be thorough. The extent to which the hazard of one salt exploding another is dangerous, is dependent upon the quantities which take part in the reaction and upon whether the reaction takes place at the bath surface or below the surface. Explosions at the surface are less dangerous but are not to be encouraged. Explosions beneath the surface have much greater relative effectiveness in the amounts of molten salt they can throw and the distances they can throw it. Salts not cleaned out of deep recesses are likely to get below the bath surfaces before the explosions take place.

Parts sometimes are cleaned by immersing in a secondary bath which will remove or "kill" the salt which is dangerous to the final processing bath.

This is a technique which seems destined to increase in use and importance.

7. *Rustproofing*

A final dip in a rust inhibiting compound sometimes must be given to the cleaned parts if they are to be stored. This should be mentioned but it is in no way peculiar to the salt bath process.

Chemical Effects

Salt baths may be intended to have chemical effects upon the work and (rarely) on the pots, or to have no significant chemical effects. Greater care in studying these effects would benefit many a salt bath user.

Chemical effects on the work may be those of carburizing, nitriding, oxidizing, deoxidizing, and others. Beneficial chemical effects upon the pots seem to have been very little studied but are being brought to light by practical experience. An example is a known, but as yet not analyzed, chemical effect of some salts in passivating or otherwise protecting the surfaces of nickel-chromium alloy pots in such manner that carbide precipitation is inhibited, thereby delaying intergranular corrosion and lengthening pot life.

When no significant chemical effect is intended, the word "significant" may mean that there shall be no carburization, decarburization, oxidation or staining. A bath may be oxidizing in nature, as is true with the baths used for some descaling processes, and yet have an effect upon the scale only and not upon the work. In many a bath a chemical effect strong enough to put a dull finish on the work is being accepted when with a change of ingredients and procedures a bright finish could be had.

Very mild chemical effects sometimes are beneficial in baths otherwise intended to be neutral to the work. A very mild carburizing or nitriding effect may serve to correct any slight decarburization which may have occurred while a part was being transferred from one hot process to another; mild decarburization of thin surface areas can have dozens of different causes.

When work is to be transferred from one salt bath to another without an intermediate cleaning, the solubility of the first salt in the second without changing the performance of the second, or the insolubility but tendency of the first salt to either settle out or else rise to the surface of the second salt and thus not affect the performance of the second, can be highly important. As problems of this kind are solved the number of operations which include such bath to bath transfers will increase vastly.

Sludging of a bath can be caused by dirt or another salt being carried into it with the work and work fixtures, but more often is a chemical effect. Sludging sometimes is made protective to pot walls, and in one recently announced furnace, is used to protect and to prolong the lives of the electrodes. Where sludge is not intended or employed to be beneficial to equipment, a bath of carefully selected ingredients very often can reduce this problem. Examples of the salvaging of this sludge for its metallic or other ingredients were not found while interviewing for this manual.

Chemical effects often are harmful to electrodes and to pots, harmful enough to prohibit the use of some types for some salts at some temperatures. The degree of harm has wide variants and must be studied with care. Some of the greatest pot and electrode advances planned "for the near future" will eliminate many of these limitations. In the meantime, the sales literature and sales engineers of the makers of the salts, pots and electrodes planned for use together should be consulted since there seem to be wide areas of disagreement about these chemical effects, their economical effects and their real causes.

Heat and Salt

The heating action of molten salt depends almost entirely upon turbulence.

Little is said about the thermal conductivities of the salts as substances, excepting that some authorities agree that up to about 1000 F their average conductivity approaches that of lead and at higher temperatures the average is about one-third the conductivity of lead. The molten salt picks up heat from a source hotter than itself, or heat is generated in it by its own resistance to electrical currents passed through it by electrodes, then by convection or other currents (turbulence) the molecules are brought into wiping contact with the work or other colder objects where they deliver their heat and by the same turbulence are taken away to be replaced by other and hotter ones.

Practical experience indicates that in any ordinary bath the convection currents unaided by any mechanical or electrical stirring will deliver heat to the surface of a steel piece as fast as the steel can conduct the heat to its interior, but will not deliver heat to the surfaces of aluminum or copper pieces as rapidly as those materials can conduct it. The shape of the pot in reference to the points or areas at which heat is applied to or within it undoubtedly influences the volumes and velocities of these currents and the force with which the molten salt strikes the work. But these shapes and resultant currents have been studied more in relation to their effects upon the volumes of salt exposed to the air when chemical reactions take place between the salt and the air, as in cyanide baths, than in relation to the effects upon the speed with which the work is heated. Makers of fuel-fired furnaces are tending to develop designs in which the heat is applied evenly to large areas of pots rather than being concentrated on small areas, but this again seems to be mostly for prolonging pot life and reducing fuel bills and not for its effect upon convection currents.

Differences in these convection currents may explain much of the fact that even in the same plant the same salt may be found to be "erratic and variable in results" in one furnace and pot but "steady and dependable" in another. Such varied results seem to occur mostly with salts which are to have chemical actions on the work. Velocities and volumes of the convection currents can easily have effects upon the tendencies of various elements in the bath to stratify or otherwise to concentrate, the thoroughness of mixing, and the evenness with which the chemically acting substances are carried to all surfaces of the work by the salts. The practical answers to such problems are within the realm of the practical experience of the sales engineers and the bath users.

Stirring action is added to convection currents in many salt baths. It may be set up by electrical currents flowing between electrodes, or deliberately caused by pumps, impellers, air lifts, the bubbling of gases through the baths. The modern tendency to use mechanical handling devices which keep the work in constant although slow motion within the bath can en-

hance stirring action. More than one bath user reported that his results with the same salt were greatly improved by even slight increases in the stirring action.

Baths which are to take heat away from the work in process, as in austempering or martempering, almost always have mechanical stirring devices. This is because the convection currents from the hot work flow upward from the work while it is safest and most convenient to put the cooling jackets or other cooling means below the level of the work, and not because the salt otherwise lacks the ability to conduct the heat away.

The speed with which the salt bath turbulence accomplishes heating or does "high temperature cooling" is the greatest general asset of the salt bath. Although such economic limitations by no means always apply, there is many a bath in daily operation which could not justify itself economically if it did not save 80% of the heating time required by previous processes. And this high speed makes possible many a heat treating operation which without it could not be performed at all.

Specific Heat

The specific heat of any substance is the number of Btu which must be added to or subtracted from one pound of the substance to change its temperature one degree F. It differs for each state of the substance (solid, liquid, gas) and within any state differs with temperature. Some salt makers customarily publicize it for the working ranges of all their standard salts, others for only some of their salts. It can have various effects upon salt bath performance.

For a given amount of salt in the bath the specific heat will determine "how much heat will be in the bank" to draw upon, or in another comparison what the "fly wheel effect" will be when a cold load is lowered into the bath. If the specific heat is high there will be a large bank of heat. When a heavy load was charged into a bath for a 45-min. full temperature processing time, with the time during which the load cooled the bath below operating temperature being waste, a salt of a higher specific heat has been known to reduce this waste time by as much as 10 min.

Another effect is found in the frozen salt protection of the metal. When the cold work is lowered into the bath a layer of salt freezes about it and protects it from thermal shock. This layer quickly melts, allowing the molten salt to get at the metal surface and do its work. It must not be assumed that the metal remains cool while that layer forms. On the contrary, the metal first must absorb from the salt enough heat to bring the salt down from its working to its freezing temperature (usually a drop of more than 100 deg.), and then the metal must absorb the latent heat of fusion which any substance gives off in changing from its liquid to its frozen state at a constant temperature. This latent heat of fusion must go into the metal, it cannot go from the freezing salt layer to the hotter molten salt which surrounds it.

Salt of high specific heat tends to remain fluid longer and to drain better than others. But some shops report evidence that, in work having deep and small diameter blind holes and similar recesses, and with short time cycles of immersion of the work in the bath, the salt which freezes in the bottoms of these recesses may not unfreeze before the work is removed from the bath, and that this is more likely to happen with high than with low specific heat salts.

Such unfrozen salt, of course, presents a cleaning problem. But all the phenomena which lead to "plugged holes" may have more to do with sharpness of salt melting points than with the other factors to which they usually are credited.

Working Ranges

Salt makers commonly assign to their salts working temperature ranges which begin at lower points reasonably well above the mushy ranges and end at upper points well below the temperatures at which the salts will break down or otherwise behave improperly. Some salts are said to become violently reactive and even explosive if carried too high above their working ranges.

The high and the low points of the working ranges of some salts may be exceeded if this is done under the advice or with the consent of the sales engineers who sell them.

Narrow working ranges sometimes are best for repetitive operations or when the baths are not required to be flexible in application.

Extending the upper limit of a working range sometimes merely means that the bath will exude more of a carbon or other "cover material" at its surface, or conversely, that special carbon or other cover material has to be applied to the bath surface. If this creates no uneconomical work cleaning or other problem, then the working range may be extended.

Lower points of working ranges sometimes can be reduced if the furnace or other heater is given additional heating and stirring ability to keep the bath temperature from ever getting too low, and better still, if that added heating is accompanied by a more sensitive automatic control to make sure that the additional heat is applied quickly and in sufficient volume.

The lower point sometimes can be reduced if the weight of the work load is to be reduced, or if the bath contains sufficient salt so the bank of reserve heat is high, or if a salt of the same type but higher specific heat is substituted.

So long as dangerous temperatures are avoided the establishment of a working range always is a matter of practical application.

Wide working ranges are advisable when the bath must be flexible to accommodate work loads of highly varying weights and surface areas. A bath which is to be loaded with a few pieces of thin and easily distortable sections can be reduced to a point as close as its lower limit as the heat treatment or other operation permits, thus securing the frozen salt coating protection quickly and minimizing the thermal shock. If the load is to be of thicker and heavier pieces then the temperature can be raised so more heat enters the work before the protective coating forms and so the bank of reserve heat in the bath will be higher, thus speeding the operation. And, of course, a bath of wider working range can apply more ranges of temperatures required for specific treatments.

Salt baths can have different chemical actions at different segments or areas of their working ranges. A cyaniding bath of wide working range, for example, puts relatively more carbon and less nitrogen into the case at the upper limits of its working range, but more nitrogen and less carbon at the lower limits. Since the nitrided case is harder but thinner, but the extremely hard carburized case is deeper but softer, the heat treater can vary

his temperatures to obtain various desired effects.

Drag-Out, Viscosity, Specific Gravity

Technically, drag-out consists of the salt which clings to the work and work fixtures when the work is removed from the bath. Practically, some baths form crusts which must be removed from time to time, some baths smoke or vaporize continually, some elements burn continuously at the bath surfaces, some baths sludge heavily and must be cleaned often, and the losses of salt from all causes are lumped and called drag-out by the bath operators.

Operators often relate actual drag-out to the viscosity of the salt. But viscosity is a word which, in spite of the vehement protests of engineers, still variously means (1) fluidity or ability to flow through a hole, (2) adhesiveness, and (3) liquidity in the sense that any substance low in liquidity will not readily flow over a surface nor permit currents to flow through itself nor permit forward motion of solid objects moving through it. Some engineers and some sales literature use "fluidity" in the sense that this manual uses "liquidity," and the reverse, and others agree with the meanings, or with modifications of them, which are used here. No attempt to decide which meanings are correct is intended; warning merely is given that care must be used when comparing discussions.

All salts commonly used in salt baths are highly fluid. They penetrate such tiny openings that pots made of any materials likely to be porous must be tested with gasoline or some other highly fluid material. Water cannot be used for this testing; the salts will penetrate where water will not. This may not apply to some of the special salts, although no such cases were encountered when researching for this manual.

Some salts are more adhesive than others and tend to adhere to the work and the fixtures when the work is withdrawn from the pot. And some salts form, or must have added to them, highly adhesive top coverings. Adhesiveness tends to increase drag-out.

The loss of liquidity which causes molten salts of high fluidities to plug small holes and form heavy coatings seems to have no completely satisfactory explanation. It does have a direct effect upon drag-out, and it can so increase cleaning problems as to make some salts uneconomical for some operations.

Drag-out has to be studied in relation to bath rectification or other property restoration, to cleaning costs, and to salt costs. Often it is insufficient to make way for the amounts of new salt needed for rectification.

No examples were found of low liquidity impeding the motion of mechanically handled parts to such extent that distortion of parts was caused. Nor were there any cases of low liquidity causing difficulties in the setting up and holding of parts for brazing or soldering.

The specific gravities of molten salts vary, but range from 2 to 3 times that of water. In one instance a piece of steel which had to be processed in two different salt baths weighed 7.5 lb. in air, about 4.5 lb. when immersed in one bath, and about 5.5 lb. when immersed in the other. This high specific gravity supports the heat weakened metal and reduces warpage.

Warpage of parts heat treated in salt baths sometimes is reduced more than 90%, setting up brand new possibilities of machine parts design and of sequences of grinding and machining and other fabricating operations. But not all of this reduction can be credited to the specific gravity and the resulting work support of the salt. A great deal is caused by the low thermal shock and the high speed even heating in the salt bath. And some is achievable because the salt bath permits such adaptable use of supporting fixtures.

No examples were found of warpage being still further reduced by changing to a salt of higher specific gravity.

Liquid Bath Case Hardening

There are several means by which salt baths can impart hard cases to steel and to some other metal parts. For decades cyaniding or "skin hardening" was the only one of these which was generally known, and it has been convenient for salt and equipment methods to relate or derive their explanations of the newer methods to cyaniding, to explain them as "kinds of cyaniding." But lately it has been realized that so many different results can be obtained by variations and combinations of the processes that they are being lumped together under various trade names which add up to "liquid bath case hardening."

The type of case imparted can be widely, but far from completely, controlled to suit its function. The type of case obtainable is limited a great deal by physical and chemical factors and a great deal more by economical factors. Thus, it is possible to get an extremely hard case which is thin and brittle, but not an equally hard one which is thick and resilient or pliable, and so on.

Decision as to the kind of case to obtain can depend upon several factors. The order of their importance will vary with the functions of the parts to be hardened. Among them are:

1. *Permissible wear*

In this "age of accuracy," increasing numbers of parts will continue to function only so long as they maintain high dimensional accuracies. A few ten-thousandths of an in. of wear could scrap such a part. For these, liquid bath cases which lack only a tiny bit from being true nitriding (they are called "salt bath nitrided") and which have hardnesses corresponding to 1100 Brinell may be preferred.

2. *Surface finish needed*

Some parts have such contours, or because of grain growth can be allowed so little "time at temperature" in the bath and therefore must form such thin skins, that corrective grinding or other operations after hardening are impossible and the surface finish must be the "as hardened" one. And a great deal can be done in the selection of the salt and the equipment, and the control of the operation. The cleanability of the salt from the work is important in these circumstances.

Sometimes the surface finish must remain as hardened because the extreme hardnesses of the hardest of skins penetrate too little beneath the surface to permit effective grinding.

There are instances in which the parts which have been case hardened by salt bath or by other processes, or even have been through hardened, are "re-cased" in a salt bath to correct any decarburization and to put an extremely thin but hard surface over the hardened supporting metal. Such parts, of course, have surfaces "as hardened."

3. *Special surface effects*

Salt baths can color parts. The purpose may be to create a salable finish, to "kill" the reflectivity of light from their surfaces so the eyes of men working about them will become less tired, to add to corrosion resistance, to provide a minutely thin special surface which when subjected to such bearing pressures as those exerted by chips upon tools will be high in lubricity for the brief time that they wear and thus will aid in the "break in," and to aid in ease of identification of parts when in storage or when installed but in the vicinity of other parts of similar shapes but different functions.

4. *Correctability*

Parts which have been case hardened may need subsequent corrective operations for dimensional accuracy, for surface finish, for distortion, and for selective or other assembly methods. Some of these operations involve grinding or other surface finishing, others do not.

Some case hardening methods produce "zoned" cases which make surface correction necessary as well as practical. True nitriding, such as is done in muffle furnaces and with ammonia gas, is one of these. It has a "white layer" on the outside which is produced at the beginning of the nitriding cycle and which is at once softer than the true effective zone and so brittle that if not ground away it is likely, in some applications of parts, to cause failure by chipping or spalling away. This grinding can provide an opportunity for dimension and finish corrections.

True martensitic carburizing, by contrast, goes straight in from the surface at a constant hardness. The depth of the true martensitic zone is subject to control by proper selection of salts and procedures, as indicated under the subhead "example of a change of salt" in this manual. Truly martensitic depths as great as 0.010-in. were produced in only one hour of immersion of parts in the shop cited in that example. This leaves far more than enough grinding stock for the improvement of surface finish alone. It leaves enough grinding stock for nearly all occasions on which dimensional correcting must be done to align or position one area of the part with another, or to align or position or correct the critical or the control areas of the part in accordance with those of another.

By varying salts, temperatures, immersion times and other procedures the cases obtained in salt baths can be varied from those which are very nearly true nitriding with only tiny proportions of carburizing, on through a scale of proportions of nitrogen to carbon in the case, to those which are very nearly true carburizing with only small traces of nitrogen in the case. The possible but controllable variations of this upon zoning in cases and upon depths and hardnesses of cases are so many that some day some metallurgical scientist is going to write a thick book about them. In the meantime, by practical experiences and in consultations with the sales engineers the shop men are learning how to obtain from their salt bath case hardening the desired depths and hardnesses of cases for the desired correctabilities.

Correction for selective assembly sometimes is done by slight bending or other deforming of parts. Shop men report that parts carburized with very low nitrogen content in the case but with case depths of over 0.008-in. can be bent in this way without cracking or damaging the case, but that cases high in nitrogen cannot.

Similar corrections are made for distortion caused by hardening. It must be emphasized that salt bath hardening causes little distortion in the heating bath itself, and that methods of salt bath interrupted quenching can reduce quench distortion by more than 90%. But for some thin parts of complex contours some shops find it more economical to avoid the fixtures which would be needed to eliminate distortion in the case hardening baths, and to quench directly into oil or water from those baths, doing any necessary correcting for distortion by letting the assembly line operators bend the distorted parts back into shape.

5. *Shock resistance*

Parts subject to shock loads or to stresses of the kinds which produce mild creep strains usually are given cases of the less hard but less brittle carburized types with very little nitrogen in the cases. The gradient at which the hardest or truly martensitic area of the case shades off into the toughened core of the piece is subject to wide selectivity and close control in salt baths. A carburized part must, of course, be quenched in order to be hard. Shock loaded salt bath case-hardened parts often are cooled, cleaned, reheated in secondary salt baths and then quenched for better control of shock resistant properties.

6. *Metallurgical control*

Salt bath case hardening temperatures, and with them the carbon-nitrogen ratios obtained in the cases and the other case characteristics, often are varied in accordance with the metallurgical condition desired in the interior or the core of the steel. A single quenching operation direct from the case hardening bath then hardens the case and toughens or otherwise conditions the core. Dependent upon the possible grain growth and other factors if the steel in question should be quenched from a temperature materially above its upper critical, the case hardening may have to be done at a temperature which imparts more nitrogen or carbon than otherwise would be desired.

Grain growth is a matter of time at temperature as well as of temperature alone. Very often an accelerated case hardening procedure in which the salts contain catalysts to speed up their action can permit a steel to be held at a good carburizing temperature for a time period so short as not to be damaging and yet can provide an adequate case.

Nitriding usually is done at temperatures too low for quenching and yet, for many steels, not too low to cause grain growth if the time period is long enough. All core toughening heat treatments then must be carried out before the nitriding is done. With 20-hr. gas chamber treatments there may be grain growths at nitriding temperatures, with resultant changes of dimensions, warpings, and changes of physicals. Salt baths often can perform this same operation in 3 hr., with resultant reductions in grain growth troubles.

7. *Combined operations*

Very often several different parts requiring different depths and characteristics of cases are simultaneously case hardened in the same bath. The time during which each part is immersed can be varied at will, the temperatures of the various parts of the bath cannot.

8. *Bulk operations*

Production economies may call for handling bulk lots of parts in baskets or other containers. This brings problems of compromises or of "average" results which are quite similar in nature to those found on automatic

screw machine operations, automatic punch presses, or any other bulk lot production methods. The compromises are mostly those of time cycles *vs.* tooling.

In one instance small cylindrical parts needed carburized cases which for best performance should not be less than 0.011-in. nor more than 0.017-in. deep. An accelerated type of salt which contained a catalyst was selected. Experiments were made with many sizes of wire baskets as containers for the parts. It was found that with a round basket 15-in. deep by 5-in. inside dia. the parts at the outside of the load would receive no case deeper than 0.016-in. and those at the center no case shallower than 0.012-in. An electrode type furnace which would provide strong and continuous automatic stirring action to aid the convection currents permitted the baskets to be of these sizes. The pot selected was rectangular, 30-in. long by 15-in. wide by 18-in. deep; it would permit 7 basket loads to be treated at one time while providing plenty of space for the molten salt currents to circulate around all of the baskets. The parts were quenched directly in oil from the 1575 F casing temperature, then placed in closed-end baskets which were mounted in the horizontal position on studs and with their lower halves immersed in running water, then were revolved slowly to act as tumbling barrels to clean the work.

If these pieces were processed in much smaller quantities then a different type of case, obtainable in less total heating time, might be more economical. So long as the case obtained is suitable for the purpose of the product the salt bath user has wide latitude for selecting his kinds of salts and equipment and this permits him to apply the highest grade of methods engineering.

9. *Continuous operations*

Some case hardening baths form surface scums, others do not, some must have surfacing materials added, with some the rate or likelihood of scum formation is dependent upon whether there is any such abuse as carrying dirt into the bath with the work, with some the surfacing or "top" is added merely as a heat insulator and an economizer of bath ingredients and may be omitted if economy indicates.

Some baths depend upon chemical reactions between bath ingredients and the air and the sizes of their surfaces exposed to the air determine very largely the type of salt and the bath temperature which will cause these reactions to keep the bath ingredients at optimum values. This problem often is complicated by the forming of scum which varies the amount of bath surface actually exposed to the air.

Continuous flow conveyor systems which automatically take parts into and out of baths can be arranged to automatically push the scum or the top aside upon ingress and egress of their loads, or they can be permitted to drag some of it out as their loads emerge, or a salt and a bath temperature can be selected with which the scum or top problem does not exist. The continuous flow is likely to have enough of a stirring action on a bath which reacts with the air, and the bath surface in order to permit continuous movement of the load may be large enough, so this reaction problem becomes difficult.

Combinations of all these problems are likely to indicate that one type of salt, used at one narrow temperature range, is best for a specific job. To the extent that this happens the bath user is limited in the type of case which he will obtain. In a great many instances it has been found best to modify the steel or change the design of the product so that this case will be appropriate. But in the greater number of instances the salts and temperatures to produce the desired cases should be selected and operating economy compromises made or materials handling equipment and materials cleaning methods improved to get the desired type of case within a reasonable cost.

Types of Liquid Bath Case Hardening

It has been convenient for sellers of salts and equipment to divide the types of liquid bath case hardening operations into identifiable categories. But if the engineering reader finds some of the salt bath sales literature to be a bit vague and indefinite about what to expect of each category and what operation belongs in which category, it is because many operations belong partly in one and partly in another, many could equally well be assigned to two different ones, and some do not seem to belong to any of the present categories.

The following list of categories is based upon (a) what the sales literature says, (b) what the sales engineers seem to think the literature means, and (c) what the production men of salt bath users seem to think the sales engineers mean by what they say. *This manual strongly urges materials and process engineers to tell the salt bath sales engineers what results they want and what they are willing to pay to get them, and never mind what the processes by which they get them are called.*

The types or categories of salt bath case hardening are: plain cyaniding, accelerated cyaniding, carburizing, nitriding, and tool steel surface hardening.

Cyaniding. Plain or "simple" cyaniding is one of the oldest and most widely understood salt bath processes. The baths are operated, generally, at temperatures ranging from 1050 to 1600 F. At 1050 F the case imparted is almost pure nitride and is very hard but somewhat thin and brittle. As the selected bath temperature is raised the operation becomes less that of nitriding and more that of carburizing, the case then being less hard but less brittle. By the use of patented processes ammonia and other gases can be bubbled through the bath. The ammonia adds more nitrogen to the case, the other gases have peculiar effects such as catalyzing the bath to speed up its action and also reducing the cleaning problems of some salts.

Run in an ideal way, the bath should have chemical testing in accordance with the instructions of the salt makers to make sure that its cyanide concentration is correct, and this should be done at least once each shift. But many practical operators prefer to harden and break a test piece and judge the condition of the bath by the depth of the case obtained.

In spite of the decades during which this process has been well known it still is being improved. Improvements mostly consist of adding catalysts, with the result that it is hard to tell whether the process then should be called plain or accelerated cyaniding.

Plain cyaniding generally is not con-

sidered economical for case depths of over 0.008-in. Economy is further affected by the fact that cyanide in the bath must react with the air at the bath surface to form cyanate which does the actual work, and that this reaction continues so long as the bath is molten, thus making it advisable to shut down the bath when not in frequent use. Careful studies must be made of the amounts of cyanide to be added to replace that broken down by the reactions; the amounts varying with the nature of the work, the amount of drag-out, the area of bath surface exposed to the air, and the scum or top which restricts the actual exposure of the salt to the air.

The greatest assets of the cyanide bath are the variability and controllability of the type of case imparted, and the large number of operators who are widely experienced in its use.

Accelerated Cyaniding. The accelerated baths are run at higher temperatures than plain cyaniding, the range being generally 1550 to 1650 F. They are economical for cases as deep as 0.030-in. for most work, and many users produce cases to 0.060-in. with them. The cases generally are lower in the nitriding and higher in the true carburizing quality than those obtained by plain cyaniding. In fact, many users bubble ammonia through these baths in order to be sure to get enough nitrogen.

The replenishment of cyanide content is not so critical a control operation as with plain cyaniding, especially if calcium cyanide instead of sodium cyanide is used, or the salt is one of the many newly developed types which are high in catalytic effects. Many of the newest developments are of these "catalytic salts." They have mixed and not fully known effects upon bath economics including the problems of cleaning the parts.

Carburizing. Molten salt carburizing baths can impart cases as deep as those obtained by any other carburizing method. The economical limit of that case depth usually is considered to be 0.25-in. Very rarely is the case made any deeper than 0.125-in. The great majority of cases range from 0.100-in. down to 0.060-in. The process is nearly opposite to plain cyaniding although both processes make use of cyanide. In the plain cyaniding the atomic nitrogen is absorbed into the case while the carbon monoxide is breaking down into free carbon and oxygen so the carbon can be absorbed, and the nitrogen inhibits the absorption of the carbon, thus tending to produce a thin case which is as high on the nitrogen side as the temperature and other conditions will permit. In the carburizing the use of alkaline earth catalyzers prevents the release of very much active nitrogen by inhibiting the formation of cyanate. This leaves the liberated carbon free to do its work unhampered by the nitrogen.

The movement of some nitrogen into the outer skin of the case is sometimes considered to have the desirable effect of producing a somewhat harder skin over a very hard case. Nitrogen can be added by running the bath at the lowest temperature, about 1600 F, which is considered to be truly carburizing, and by bubbling ammonia through the bath. A heavy load immersed in the bath has the effect of dragging down the bath temperature until the salt freezes, and as this salt melts the steel is for a brief time at the best temperature which that bath can provide for any free nitrogen in the bath to enter the case. Experiments with "cyclic carburizing" are reported, the bath being held at its lowest carburizing and best partial nitriding temperature for one period of time and then raised to a higher temperature for completion of carburizing. This practice does not seem to have become general enough so its true results can be evaluated.

The bottom limit of temperature is about 1600 F (although some specially catalyzed baths are run at 1550 F for higher nitriding effect) and the top limit is about 1750 F. Pot maintenance troubles are the greatest top temperature limitation, but types of pots which will raise this limit are said to be about to be announced. Metallurgical conditions desired in the cores of parts also are temperature limiters.

Additional carbon supplies may be had by adding carbonaceous top materials to the baths and by bubbling hydrocarbon gases through the baths. The higher the bath temperature for any given amount of cyanate in the bath the lower the nitrogen content and the higher the carbon content of the case. This, of course, holds true for any kind of salt bath case hardening.

The carburizing process has high speed, freedom from distortion of parts, exact controllability in that the temperature and the time of the work at temperature are so easily controlled, great flexibility in that the time at temperature of various batches in the same bath can be so easily controlled or the action of the bath can be so easily varied. This carburizing can have just about as complete freedom from oxygenation of the case as the laws of chemistry permit. It is causing the development of a great many completely mechanized systems.

POTS FOR SALT BATH TREATMENTS

Tanks or pots for salt bath heating are of a variety of types differing in materials and shapes in accordance with the type of salts used and with heating methods employed.

Materials used most frequently for pots are:

Cast or pressed seamless steel
Cast or welded alloy
Cast iron
Ceramics

Often the choice of material and then in turn the type of salt is based upon the method of heating. These heating methods are all used widely in connection with salt bath heating:

External heating by means of direct oil or gas flame
External heating by electric resistance coils
Internal heating by immersion resistance units
Internal heating by immersed electrodes
Internal heating by radiant tubes through the furnace

Nitriding. Nitriding is the one salt bath case hardening method about which the most controversy seems to exist. Mutually accepted facts seem to be that it is at least twice as high in speed for the same case depth as the "dry" or closed chamber ammonia gas nitriding and that it is more uniform in results.

Highly responsible bath users report, but off the record, that they get the same case depth in 3 hr. in the salt bath that they got in 20 hr. by dry methods. Salt and equipment makers confirm this. But it is not a claim that the salt bath industry wants to make at this time.

There are claims that salt baths will not nitride nitralloy, nor will they duplicate the results on aluminum bearing steels that the dry process can achieve by holding temperatures down to 950 F. Counter claims state that special salts and procedures will nitride any metal that can be nitrided at all. Middle of the roaders say that this latter is true but that the salt bath is economical for such alloys only if the production lots are too small to warrant setting up a 20-hr. process.

Grain growth is another much debated point. The amount of grain growth is a function of the metals involved, their metallurgical conditions previous to the start of nitriding, of nitriding temperature and of time at temperature. Claims are made, and disputed, that the salt bath nitriding temperature is necessarily 50 deg. higher than that of the dry process, and that the complete uniformity of heat application by the salt bath will eliminate any deformations caused by unevenness of grain growth within the work piece unless the work piece had segregated areas of differing granular structures before the nitriding operation began. Not disputed is that the time at temperature in the salt bath is much lower than in the dry process.

The much discussed "white line" is another moot point. The high nitride white area which forms at the beginning of most nitriding applications is generally recognized to be brittle and to require removal to expose the "true nitride" zone beneath it. Many bath users feel that if the white line can be held to a thickness of less than 0.001-in. it does not need removal and that salt baths easily can hold it below this.

Cyclic nitriding in which the work first is held at 950 F and then is raised by temperature gradients to temperatures up to 1200 F or higher is easy to do in salt baths. The baths are high in cyanide and in cyanate. True nitriding is obtained at the lower temperatures, then as the temperatures are raised some carbon enters the case, producing a final case which has the true nitrided hardness on its extreme outer skin and an under layer which is lower in brittleness.

Cyclic nitriding in which the nitrogen is obtained more by bubbling ammonia through the bath, or by various other means which do not altogether depend upon the breaking down of cyanides, and in which the final bath temperature will be high enough so a quench will establish the metallurgical condition of the core as well as of zones of the case, is under intensive research and may be promoted for extensive commercial use in the near future.

Salt bath nitriding has proven itself highly practical and valuable. A great many valuable phases of it are in the rapid development stage.

Tool or High Speed Steel Surface Hardening. This is a nitriding operation which in increasing numbers of shops is followed by a coloring operation. On tools not subject to shock loads—thread chasers are an example—it has been known to multiply the tool life by four. On shock loaded tools it is assumed to be useless, although a great many tool rooms nitride all high speed tools "as a matter of course."

The net effects of coloring after nitriding are not completely known. They are being studied intensively by some makers of cutting oils. The colored zone is higher in corrosion resistance, has high pressure lubricity to resist chip pressure and is an antiweldant, does not endure long at the area of greatest chip pressure, undoubtedly is of great assistance at the break-in period of the tool to the elements in the cutting oils which form a "one molecular layer thick" antiweldant combination with the surface of the tool. The coloring is done in salt baths. Tool steel nitriding often is a trouble shooter, a means of overcoming unexpected difficulties of tool performance. When the nitriding alone fails to cure the trouble, many shops add the coloring operation. The coloring often cures the troubles, in some instances, in ways for which the metal cutting art has evolved no explanations. Some of the cures may be psychological.

Stop-Off Methods. Case hardening salts vary widely in the extents to which they will respect stop-off boundaries established by copper plating, by stop-off paints and compounds, or by anything else.

A great many parts have definite sections to be stopped-off, with those sections so located that the sections to be cased can be immersed in the bath while the sections to be left soft are held in the air. The sharpness with which a stop-off line can thus be established is under experiment. The molten salt creeps up the part to some extent, and present experience does not seem to have shown whether this extent is highly constant or highly variable. Authorities agree that it is safe to assume that the stop-off limit can be to the order of plus or minus 0.030 in., if the means of lowering the work into the bath are sufficiently accurate so that the "capillary creep" of the salt up the exposed portion of the work alone is responsible for the many variations.

Many bath users impart the case to the whole piece, cool the work, then use induction or gas flame heaters or salt baths to heat up only the areas which are to become hard upon quenching.

Through-Hardening, Tempering, Etc.

Any heat treating operation which can be performed at temperatures above 350 F and below 2400 F can be performed in salt baths. This includes any kind of annealing, quenching, tempering, normalizing, spheroidizing, martempering, austempering, isothermal treatment, stress relieving, preheating, and so on. With special salts handled in special pots the temperature ranges may be even greater than these.

From the steel mill to the tool room to the final heat treating steps in metal products fabricating, salt baths are permitting some of the greatest improve-

ments in metallurgical history. Some of these improvements are brand new, others are large scale uses of processes formerly used only on a small scale. Heat treating other than case hardening will sell tremendous quantities of salts, huge installations of salt bath equipment.

New Developments. One development which is under close scientific study is the "jockeying" of steels back and forth across their critical temperature ranges. The quick responsiveness with which a salt bath can impart or remove heat permits this. The procedure depends upon the fact that as a steel passes through its critical range physical work is done by its crystals, and this physical work can be made to accomplish purposes. One metallurgist reports, off the record, that by this means he has obtained in 8 hr. a completeness and fineness of spheroidizing which is superior to that formerly obtained in 20 hr. in the same die design made of the same steel specification. He expects to reduce this 8-hr. salt bath spheroidizing time while getting still better results.

Isothermal Treatments. That high speed spheroidizing experience is an example of many procedures which are generally called "isothermal" because they accomplish hardening by transformation at constant temperature ranges. Many of these are well known but not as widely used as they will be in the near future. Many are combinations of various isothermal techniques and as such are called isothermal merely because no more accurate name has been coined for them. Quite a few are so new that their users do not want them publicized until their results are better established. The field for metallurgical experiments of this kind is wide open.

The type of isothermal treatment depends upon the steel used and the results desired. The treatment is performed at a selected part of the S-curve of the steel for a single type of treatment, at various selected points for multiple types. Many multiple types result when the work piece is so thick that the thermal transfer from its interior to its exterior, or the reverse, is not rapid enough so the salt bath can hold the interior to true isothermal uniformity of temperature. Quite a few such problems can be reduced by impeller or other bath agitating means which force the salt under high turbulence against the surface of the work and from the work to the cooling walls of the pot so the quenching speed of the bath is at its maximum. Furnace and equipment improvements which will greatly reduce this problem and extend the use of the isothermal treatment processes are soon to be announced.

Another means which is under wide experiment is to use a salt which has the widest possible working range, let the bath pick up a rather steep temperature gradient when the steel is first quenched in it, then keep the bath temperature a calculated amount below that of the calculated temperature of the interior of the piece so the temperature gradient between the interior and exterior never becomes too steep. When the desired delayed quenching temperature is reached the bath temperature is held constant.

Austempering. The steel is quenched from the austenitizing temperature into a salt bath which is held at a selected temperature above the M_S point of the steel and below the knee of the S-curve. The work is held until the transformation is complete and then is cooled to room temperature.

Martempering. The steel is quenched into a salt bath which is held at a temperature just above the martensite transformation range. The steel is held there long enough to equalize its temperature throughout but not long enough to form bainite, then is cooled in air to room temperature.

Example of Mixed Operation. Because of temperature gradients between interiors and exteriors of parts, the thickness limit for parts to be truly austempered is generally believed to be less than 1-in. and that of martempering to be less than 2-in. Yet steel pieces more than 6-in. thick are being given a martempering treatment which results in an unnamed mixture of austempering and martempering and other grain structures which gives the parts more than double the shock and abrasion resistant service lives that they had with other treatments.

The steel is high alloy. A total load of 6 tons of slabs plus 3 tons of fixtures is heated to 2050 F in a furnace, then is quenched into a salt bath which is at 500 F, the temperature gradient causing the bath to rise to 625 F.

The load then is transferred to a second salt bath and reheated to 1450 F. This takes 6 to 7 hr. for heating up and soaking. During this time the quenching bath is cooled down to below 400 F. The load then is quenched again and the salt agitated to high turbulence while the sides of the pot are cooled by water spray for maximum quenching effect of the salt, and to keep the salt temperature at all times within the 425 to 450 F range.

Hardness obtained is over 60 Rockwell C.

Steel Mill Baths. Steel mill annealing loads usually are large, often take as much as 2 days to anneal by conventional methods, during which the process is "average" for the various batches annealed at the same time and the outside portions of the loads may receive different treatments than the inner portions.

Soon to be announced are salt bath installations which will break these big loads up into smaller ones, give each batch the exact cycle anneal that it needs, do a single batch in less than 2 hr.

Reheating Carburized Work. Salt bath reheating of work which has been salt bath or otherwise carburized and the entire part, or the areas of the part not stopped-off in the carburizing operation is to be hardened, is an every day salt bath procedure.

Newer is the salt bath heating of selected areas of parts which have been wholly carburized. An example is a gear, only the teeth of which are to be hard. The gear is carburized in a salt bath, is cooled, the cyanide salt is removed. Then the gear is mounted on an axis and the axis so placed that one part of the gear periphery is immersed to a point close to the tooth root. The gear then is slowly revolved by turning the axis. In about 3 min. all of the teeth are at hardening temperature and the gear is quenched.

Bath Troubles. Salt baths used for heat treatment are "neutral" in that they do not have any undesired chemical effects upon the steel, the pots, the electrodes or the work holding fixtures. The selection of a salt which will be neutral under all of these conditions sometimes requires care.

Dependent upon their original ingredients and their usage, salts tend to load up with oxides and other foreign materials which must be removed. Some of these sink to the bath bottoms and may be scooped out as sludges, others rise to the top and may be

skimmed off, others can remain in the bath and must be removed by rectification.

Rectification. The process of removing impurities which remain in the bath is called rectification. It may be done by adding special bath ingredients, by adding enough fresh salt which is "self rectifying" because it contains rectifying agents, by inserting carbon sticks either for long or short periods as the bath requires and then removing them and scraping off the foreign material, by bubbling hydrocarbon or other gases through the bath, by using electrical devices which cause the impurities to plate onto a desired member.

The rectifying process should be selected in consultation with the makers of the salt, the pot, the electrodes if any are used, and the control mechanism if it is exposed to the salt.

Rectifying devices and agents can cause slight carburizing of work not desired to be carburized, destruction of electrodes by causing them to become porous or to plate themselves onto other surfaces, destruction of pots by electro or chemical attack, increases in the problems of removing salt from the work.

The rectification is a definite element in the operation of the bath. But it should be a servant of all the other elements, never their master, and its means almost always can be selected accordingly.

Temper Shaping. The lowered strength and easy deformability which some parts have at their tempering ranges is used in growing numbers of instances to perform final shaping and accuracy-securing operations in salt baths. The hardened parts are mounted in clamps or other pressure fixtures which usually are spring actuated, then are placed in tempering baths having temperatures up to 1200 F. Tempering and forming operations thus are simultaneous.

Annealing. Annealing, stress relieving and normalizing operations in salt baths quite often involve the use of two or more baths. The first bath is high in heat capacity and is used for heating up the work. The second or succeeding ones are lower in heat capacity but higher in economy for holding the work at temperature for the desired time. The first bath may be used simultaneously for several different lots requiring different processes, in which case it is held below the final temperature of the lowest temperature process lot and each preheated lot is transferred to a bath which completes the heating of it to its desired temperature and holds it there.

Cycle Annealing. Many different types of cyclic annealing are done with high economy in salt baths. In one which is solving a difficult machining problem, a part is heated in a salt bath which heats it above its critical range to get all alloys into solution, then is quenched in a second bath for isothermal transformation. This produces too high a hardness for machining. The area to be machined is then heated in a salt bath to 1550 F and quenched in a salt bath at 1250 F, resulting in a readily machinable Rockwell 15 C hardness. After machining, this area is reheated and restored to the Rockwell 35 C hardness of the main body by a repetition of the isothermal quench. Net time saving is 50% as compared to previous methods.

Preheating. Preheating operations for forging, rolling, pressing, drawing and extruding are under experimental development and may lead to some huge installations of salt baths. The work is heated quickly, uniformly and without scale in the salt bath, and if the work bears mill scale or scale from previous hot operations the salt bath can be arranged to descale it. Selective areas of the work can be heated.

These operations were mostly developed during war emergencies. Too much seems to be assumed and too little known about their problems and advantages. For example, salt is carried with the heated work from the bath. There seems to have been no effort to find out how to use high cycle vibrations or other means to remove it. Nor are its true effects upon dies and other tools well enough known to be evaluated.

The salt is assumed to be abrasive and clogging; it may actually be an excellent high pressure lubricant. In one experiment, reported "off the record," a tool steel mill found that by heating billets in a salt bath a formation of scale which had amounted to a total of over 5% could be avoided, thus getting that much more salable steel per melt. But the scale had acted as a traction surface to help the rolls to get a heavy friction grip on the billets. The salt, by contrast, was a lubricant, and some friction producing device such as using larger diameter rolls seemed to be indicated. In spite of this, one shift could roll the salt bath heated billets without much difficulty, the second shift could not roll them. Seemingly, all that stands between this mill and the saving of high tonnages of high value alloy steels is a development of new but simple skills by supervisors and operators. This need is common whenever a new process of any kind is installed.

Wire and Strip. Wire and strip heat treating and preheating installations are among the largest salt bath equipments now being operated. Many of their possibilities are as yet unexplored. They were made originally because of savings of heating time, preventions of scale which was costly to remove and which wasted good metal, reductions of pickling costs. They have proven highly economical for temper forming and other hot forming, much of the best of which has yet to be developed. They have highly superior and largely unexplored abilities to permit stock to be first subjected to metallurgical analysis, then assigned a specific heat treatment which may include the light casing of its exterior to give the stamping dies or other production tools a clean "shear bite" but which in any instance will put the stock into the best possible condition for whatever operations are to be performed on it.

The material may be treated in coils, in which its problems are the simple ones of masses of work which must have heating times adequate to reach their interiors and salts high in liquidity and in specific heat, plus the simple problems of designing adequate hanger supports if the stock tends to deform when hot. Most such systems are conveyorized; the stock goes automatically or by crane from preheat to final heat baths and to quench and wash tanks.

Continuous methods in which the stock is uncoiled and run through the baths are in increasing use. For them the end of one coil may be quickly flash welded to the end of another so that the process never stops. Two systems are in use. In one the wire or strip goes from heating salt bath to quenching salt bath to quenching and cleaning water or other bath. In the other a salt covering is used over a lead bath, the salt preventing the lead from oxidizing and from exuding poisonous fumes and from sticking to the wire and thus damaging the tools of succeeding processes, the wire or strip

goes into the lead bath and from that to either a salt or a water quenching bath. In either system the final step can be a liming bath. In either several strands may be run simultaneously, and at differing forward speeds in accordance with their thicknesses and alloys and the amounts of cold work that must be relieved, through the same baths.

Not encountered while researching for this manual, but undoubtedly in existence, are systems in which the wire or strip goes through the bath series, is drawn while still hot, is passed through the baths a second time and again through dies. Definitely to be foreseen are systems in which the dies are submerged in the salt and the wire or strip is drawn at high temperature and without the slightest chance to oxidize, using the molten salt as a lubricant.

Stainless Steels. Among the extremely wide varieties of ferrous metals which because of their various kinds and extents of corrosion resistance are called stainless steels there are dozens of heat treatment problems for which salt baths are ideal. Stainless steels are high cost alloys and the abilities of salt baths to heat treat them without wasteful scale are important. Stainless steels of the same grade and "same analysis" can vary widely in their metallurgical behaviors and their abilities to be fabricated, and the abilities of salt baths to give individual heat treatments to individual lots in accordance with need are very important. But before being asked to take on a stainless steel problem the salt bath man must ask: what stainless, in what metallurgical condition, to be heat treated in what way and at what temperature?

Salt baths can have desirable and undesirable chemical effects upon the surfaces of stainless steels, and this is largely a matter of salt ingredients, processing temperatures, and time at temperature. While preventing scale, salt baths sometimes have slight coloring effects upon the surfaces of stainless, and these objectionable or not, depending upon whether the stainless is to have a final passivating or other process which will remove them. Stainless, especially some of the new extremely low carbon types, can be sluggish enough in its heat response so the quick heating properties of salt baths become economically ineffective, especially on work having thick sections. In short, hundreds of salt baths are doing highly beneficial work on stainless, but each new stainless application is peculiarly a sales engineer's problem.

Nonferrous Metals. Nonferrous alloys of the kinds ordinarily heat treated for purposes other than melting usually have coefficients of thermal conductivity higher than those of steel alloys. When such nonferrous alloys (they commonly are alloys of copper, silver, or aluminum) are immersed in salt baths they take the heat from the salt much more rapidly than will steel pieces of the same shapes and sections. In fact they may be capable of absorbing heat more rapidly than the bath can impart it, although this is largely a question of the specific heat of the salt, the turbulence with which the molten salt is forced into contact with the work, and of other procedures some of which are in the trial stage.

The placing of a cold load of any metal in a salt bath usually drags down the temperature of the bath to an extent which will register on the bath control instruments. When the bath loaded with these nonferrous alloys has returned to its original temperature the work pieces may be considered to be at the bath temperature throughout their sections. (This also is true of some, but not all, steel work pieces. It depends upon the thickness of section and the thermal conductivity of the steel.)

Some nonferrous alloys, especially some of the aluminums, have such grain growth characteristics that they are highly sensitive to time at temperature. With these the return of the bath to temperature may be used as a signal for instant removal. With others this same signal may be used to get work in and out for the highest productivity per bath.

Another method is to use a salt so high in specific heat and a heating method so sensitive that the bath temperature does not vary significantly as work is charged and removed. Several different kinds of work requiring the same temperature but perhaps different time cycles can be charged at once or in any convenient sequences thus keeping the output from the bath adjusted to the needs of the production operations that follow it. The work commonly is quenched in water.

For some work the baths must contain corrosion inhibitors. The question of whether these are adequate sometimes is answered by taking the pH of the bath, sometimes by more extentive chemical tests, but more usually by watching for evidences of etching on the work which emerges from the quench tanks.

Beryllium Copper. This alloy can be heat treated and also precipitation or age hardened in salt baths. One sequence heat treats the work by holding it at about 600 F for one to three hours, then age hardens it by holding it at 700 F for 15 min. A sensitive temperature control is advisable. Holding the work in steel fixtures sometimes is necessary to preserve dimensional stability.

Copper Chrome Alloy Example. Salt bath experiences in the nonferrous field seem to be divided up into hundreds of isolated examples each of which makes sense but all of which are difficult to combine into generalized statements. The annealing of copper chrome alloys used in electrical equipment is an example. The work is heated to 1850 F. Former heating methods resulted in intergranular corrosion as deep as 0.015-in., and since this interfered with electrical properties it had to be removed after annealing. Salt bath annealing reduced this intergranular corrosion to less than 0.001-in. deep, and since at this depth it had very little electrical effect an expensive removal operation was eliminated.

Sterling Silver. Pure silver will not oxidize at heat treating temperatures but the copper and other alloying elements will. Annealing operations must follow fabricating ones at frequent intervals. Salt baths perform them without oxidizing or etching, with high economy and complete control.

Clad Metals. Metals clad with aluminum, silver and other alloys often should be heat treated with as little penetration of the heat into the base metal as practical, the object very often being to stress relieve the surface or cladding metal and the bonded area. The rapid, noncorroding heating of salt baths has been found to be highly beneficial.

Magnesium Alloys. The average salt bath which would be used at the temperatures appropriate for heat treating magnesium alloys can have a violent enough chemical reaction with magne-

sium so that no magnesium alloy, and no aluminum alloy containing more than a few per cent of magnesium, should be immersed in it.

Special salts which are safe for magnesium have been reported as being past their experimental stages but have not, so far as we know, been announced as ready for general distribution.

Brazing and Soldering

Salt baths have highly economical applications for copper brazing, for hard or silver soldering, for brass brazing, and for soft or lead-tin soldering. The numbers of existing applications seem to be in that order for those types of operations.

Setting Up. The work must be so set up that the parts will maintain their relative positions while being immersed in the salt, and since the solder or braze metal cannot set until the heat source has been removed, they also must maintain their positions while being removed and cooled.

Favored methods of setting up are:
- Force or other close fits with the braze or solder metal between the parent metals.
- Tack welds.
- Clamps and fixtures.

Flux Flow. Ordinarily, the braze or solder metal cannot be guided to some areas and kept from others by fluxing only the areas on which it is wanted, as can be done with torch, furnace, or induction heating set ups. But there are successful experiments with fluxes which will do this in salt baths, and commercial operations of them may be expected soon.

Heat Guiding. Ordinarily, guiding the flow of the braze or solder metal by heating areas in the sequences of the desired flow cannot be done in salt baths. But there are examples of doing it successfully and economically in salt baths, and the tricks of it are rapidly being worked out and being made available to sales engineers.

Fluxing. Depending upon the metals to be joined, their surface conditions, and the braze or solder metal, fluxes can eliminate oxidation of the fluxed area, partially deoxidize it if slightly oxidized, and have chemical effects which cause the braze or solder metal to take hold. Salts alone can prevent oxidation under heat. Salts having special fluxing ingredients can perform some of those deoxidizing and chemical effect functions. Some of the most highly special, highest cost salts are used for brazing and soldering operations. But many of these operations are performed with very low cost salts.

Action of the Salt. Since molten salt will enter the finest of crevices there is no hope of so setting the work up as to keep the salt out of the area to be brazed or soldered. The braze or solder metal as it softens and flows displaces salt and wets desired areas.

Descaling

Metals which become scaled in heat treating operations can be descaled in salt baths with high economy and large savings of good metal which otherwise might be wasted. Several such baths are at work in steel mills and other plants. Their number may be expected to increase rapidly.

Salt bath descaling may be by deoxidizing the scale or by oxidizing it.

Deoxidation Descaling. This generally is done in sodium hydride baths. The sodium hydride, a powerful deoxidizer, is generated by bubbling hydrogen or dissociated ammonia through a generator tank which contains caustic soda and metallic sodium. This tank feeds to the main tank which contains caustic soda and sodium hydride at about 700 F. The metal to be descaled is lowered into this bath, allowed to remain there until the cooled bath returns to temperature, then is removed and quenched in water. The water forms steam beneath the loosened scale and blasts the scale off from the metal.

Oxidation Descaling. This is done in a caustic bath which contains some ingredients of unknown analysis. The bath temperature is over 900 F. The oxidation weakens the scale so it either blasts off in the water quench or is easily removed in subsequent pickling.

Other Processes. New processes better applicable to some operations are reported to be nearly ready for commercial application.

Principal Producers of Heat Treating Salts

Electrochemical Dept., E. I. du Pont de Nemours, Inc., Niagara Falls, N. Y.
E. F. Houghton & Co., Philadelphia, Pa.
Park Chemical Co., Detroit, Mich.
A. F. Holden Co., New Haven, Conn.
American Cyanamid & Chemical Co., New York, N. Y.
G. S. Rogers & Co., Chicago, Ill.
Bellis Heat Treating Co., Branford, Conn.
The Heatbath Corp., Springfield, Mass.
Kali Mfg. Co., Philadelphia, Pa.

Acknowledgements

In addition to this list of salt producers, the following firms are hereby acknowledged to have contributed information and suggestions in the compilation of this manual:

Ajax Electric Co., Inc., Philadelphia, Pa.
American Gas Furnace Co., Elizabeth, N. J.
Bellis Heat Treating Co., Branford, Conn.
Commerce Pattern & Foundry, Inc., Detroit, Mich.
Continental Industrial Engineers, Inc., Chicago, Ill.
Dempsey Industrial Furnace Corp., Springfield, Mass.
Eclipse Fuel Engineering Co., Rockford, Ill.
Electric Furnace Co., Salem, Ohio
General Electric Co., Schenectady, N. Y.
A. F. Holden Co., New Haven, Conn.
W. S. Rockwell Co., Fairfield, Conn.
R-S Products Corp., Philadelphia, Pa.
Surface Combustion Corp., Toledo, Ohio
Upton Electric Furnace Div., Detroit, Mich.
Vulcan Corp., Philadelphia, Pa.
Westinghouse Electric Corp., E. Pittsburgh, Pa.

A monthly department dedicated as a forum for the interchange of ideas between readers and editors. All readers are urged to take advantage of this space and participate in the discussions presented.

CONTENTS NOTED

Oil-Drum Furnace

To the Editor:

I noticed an interesting condensation in the January issue of MATERIALS & METHODS, digest section, page 128, describing an oil-fired ellipsoid furnace. Building and experimenting with metal melting furnaces of unusual designs, and using all types of fuels, both liquid and solid, or combined, has occupied most of my available spare time for a number of years. The ellipsoid furnace you describe recalled to my memory a similar furnace I experimented with at one time, in melting high test irons in an oil fired furnace.

I looked up the notes I preserved on this furnace and herein give a brief description of same and a summary of my experiments. This furnace is of the horizontal type, combining features of an air furnace and an iron cupola. My experimental furnace was built of 60-gal. capacity oil drums, comprising a horizontal section of 3 oil drums fastened end to end, and a vertical stack consisting of 2 oil drums bolted together and lined to 16-in. inside dia. with fire brick, and mounted on one end of horizontal section, which is also lined with fire brick, to shape an oval hearth in the center with a bung top section that can be removed, with lining attached for ease in cleaning out. The lining is funneled toward the front of furnace to opening that admits flames from oil burner into hearth. At the rear end of furnace the lining narrows and rises somewhat to the base of vertical stack. Tap out spout is located on one side of horizontal part and slag notch on opposite side. In operating this furnace the scrap is dropped into vertical stack with about 2% limestone for flux. The flames sweep across hearth from oil burner and strike against charge in vertical stack. The molten iron runs into hearth where it collects, is slagged and tapped out.

It is advisable to use a pyrometer to check temperature of iron in this furnace, as the iron may become oxydized from the excessive heat that can be generated in a furnace of this type. Temperatures of 2900 F and more can be produced and close metallurgical control exercised over irons melted.

J. J. Paul
North Baltimore, Ohio

Mr. Paul's experiments in furnace building are interesting and should be of practical value to those wanting to build inexpensive furnaces for melting metals.—The Editors.

Corn and Btu's

To the Editor:

Apparently you don't think corn cobs are so hot. At least on page 7 of the January issue you are conservative by a factor of 2,000. I hope J. L. does not take offense at the cool coal you talk about.

Aside from such obvious and superficial stuff, I find your magazine an excellent source of current information in the field of materials and methods. Your Materials Outlook section is timely and informative. I hope you have better luck than the Chicago weatherman in your predictions.

James D. Cole
Cole Electric Co.,
Park Ridge, Ill.

Thanks for the nice comments. We hope Mr. Cole and many other readers will find "The Materials Outlook" department of real help. As to the coal vs. corncobs matter, see below.—The Editors.

More Corn

To the Editor:

As one who acquired a ridge on the nose from drinking corn out of a Mason jar, I believe you do the corn cob a great disservice in stating the Btu value as 7,980 per ton. No doubt John L. Lewis will write you a letter also for implying that coal provides but 13,000 Btu per ton.

Robert C. Onan
Lindberg Engineering Co.,
Milwaukee 3, Wis.

This month's prize for eagle-eyed reading goes to both readers Cole and Onan. As Mr. Cole indicates, it is probably too greatly on the side of conservatism to use a safety factor of 2,000. Perhaps the coal having a Btu value of 13,000 per ton was some mined during Lewis' last struggle with the Department of Justice. To those not paying attention to Btu's, such values should have been expressed in pounds.—The Editors.

NUMBER 134
March, 1947

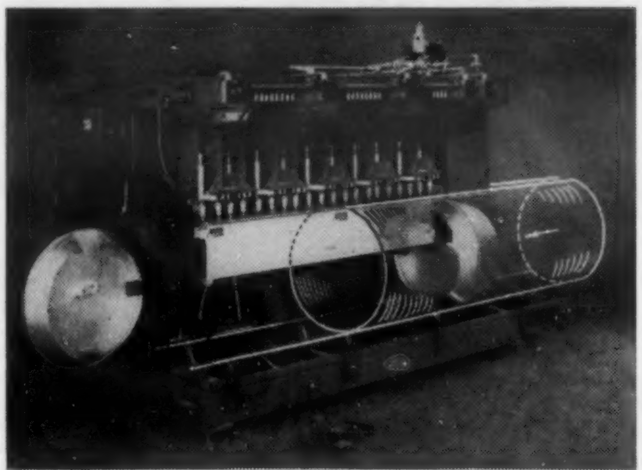
MATERIALS: .... Plastics
METHODS: .... Grinding and Polishing

Abrasive Finishing of Plastics

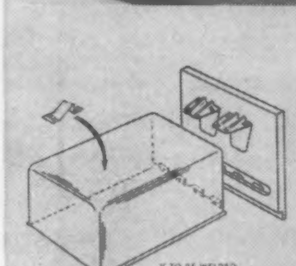
A tabular summary of a series of case studies involving the abrasive finishing of plastic parts is presented below. Under the "Characteristics of Grinding Wheels . . . Used," the type of abrasive is abbreviated as follows: Alum. Oxide = Aluminum Oxide, and Si. Carbide = Silicon Carbide. These data were adapted from *Grits and Grinds,* Vol. 37, Nos. 1 and 7, published by the Norton Company, Worcester, Massachusetts (1946).

Product	Description of Material	Description of Operation	Characteristics of Grinding Wheel (or Abrasive) Used: Type of Abrasive	Grain Size	Grade (Hardness)	Structure	Bond	Coolant
Molded Phenolic Parts	Miscl. parts molded from phenolic (thermosetting) resins	Removing burrs, gates and flashings, flaring cup wheel used	Alum. oxide	54	Very soft	Open (porous)	Vitrified	None
		Surface grinding to clean or shape	Alum. oxide	54	Very soft	Open (porous)	Vitrified	None
		Cut-off	Si. carbide	60	Medium	—	Resinoid	None
Cast Phenolic Parts	Miscl. parts cast to shape from phenolic compounds	Cutting thin sections from small cast bars using cut-off wheel 0.045-in. thick	Si. carbide	90	—	—	Resinoid	Water
Plastic Beads	Cast phenolic rods	Centerless grind (rough) using a formed wheel	Si. carbide	46	Medium hard	—	Vitrified	Water
Cast Phenolics	Cast phenolic parts	Form grinding operations performed on semi-finished castings	Si. carbide	60	Soft	Medium	Vitrified	Water
		Removing grinding marks from finish ground castings by hand polishing on soft muslin buffs 14-in. OD, up to 8 in. wide, running at 2000 rpm. (Wash in water to remove pumice.)	Pumice	#00	Pumice mixed with water to form thick paste			
		Finish polish—using buffs similar to above (running at 2500 rpm.)	Both tripoli and silica	—	Polishing compounds mixed with water to form thick paste			
Laminated Plastic Tubing	Laminated paper (impregnated with phenolic varnish) tubing	Centerless grind tubing (through feed, removing 0.020-in. stock per pass)	Si. carbide	36	Medium	Medium	Vitrified	Water
Methyl Methacrylate Parts	Methyl methacrylate is a thermoplastic and must be ground quickly, with minimum heating and loading of the wheel	Cut-off	Si. carbide	60	Medium	Dense	Rubber	Water
		Cut-off (when no coolant can be used)	Si. carbide	60	Soft	Open	Resinoid	None
Tubing, Rods	Cellulose nitrate	Centerless grind	Si. carbide	36	Medium	—	Vitrified	Water
Bullet-Resistant Glass for Bombers	Blocks of laminated (5 to 9 plies of glass with clear vinyl acetal plastic sheets between each) 1½ to 3½ in. thick	Grind sides of rough-cut blocks for size accuracy; depth of cut, 1/32 in.; table speed, 90 in. per min.	Diamond	80	—	—	Metal	—
Bullet-Resistant Glass for Tanks	Blocks of laminated glass 2 by 3 by 8 in.	Cut 3-in. thick sheets into blocks using a 16-in. dia. cut-off wheel mounted on the spindle of a large surface grinder; cutting speed, 18 in. per min.	Diamond	—	—	—	Metal	—
		Grind radii on each end of blocks using a 16-in. dia. cylindrical type wheel with a 1½-in. wide rim	Diamond	46	—	—	Metal	—

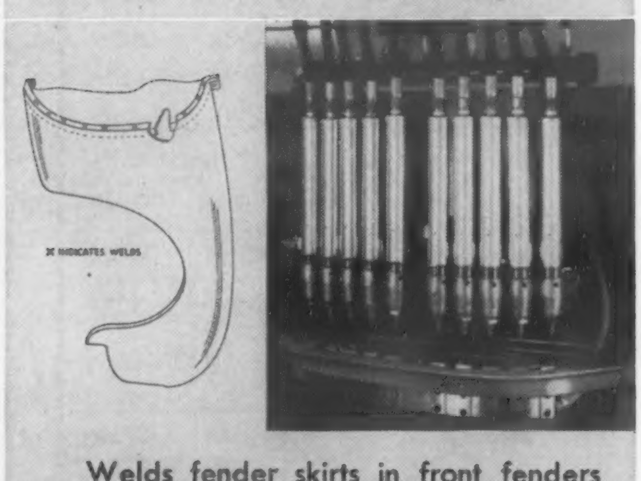
Prepared by Robert S. Burpo, Jr.



Welds 3 sizes of shells for water heaters, from rolled sheet. Straight line production. 20 guns index automatically to make 40 welds. Five twin-secondary transformers. Automatic sizing (by cones); automatic clamping and unloading (left cone is air operated). Right cone and guns adjustable for different lengths.



This machine can bat out 300 steel drawers per hour in 3 sizes. Twelve welds per drawer. Three twin-secondary transformers. Automatic clamping and shuttling.



Welds fender skirts in front fenders with 10 simultaneous welds. Three twin-secondary transformers.

The low-down on MULTI-TRANSFORMER MULTI-SPOT WELDERS

Progressive multi-transformer machines are "tops" when it comes to extremely high production. This is due to:

1. **Simultaneous spot welding (10 to 30 welds per sec.).**
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To Design Engineers—

In designing sheet metal parts for fast assembly on Progressive Multi-Transformer machines, remember to:

1. **Space welds at least 1¾" apart whenever possible to allow room for guns.**
2. **Where closer spacing is desired, locate welds in patterns (straight lines, curves, etc.) so that the guns can be automatically indexed singly or in groups to obtain required spacing.**
3. **To take full advantage of machine speed, design parts for quick loading. Where possible, provide for pre-loading of sub-assemblies.**

Progressive's Process Engineering Department will be glad to help you design for lowest overall cost per piece.

IT PAYS TO WELD

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RESISTANCE WELDING EQUIPMENT

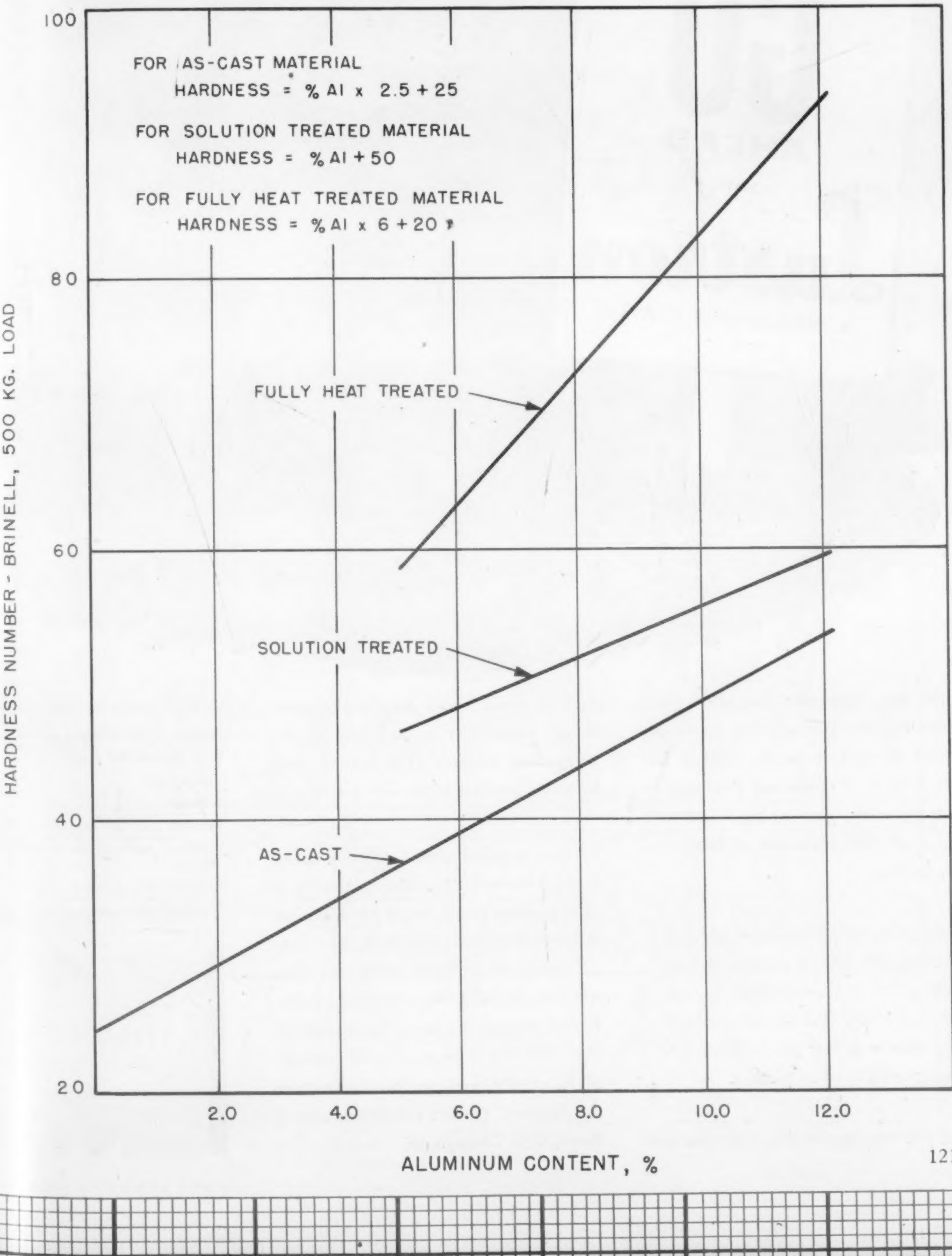
MATERIALS & METHODS Engineering File Facts

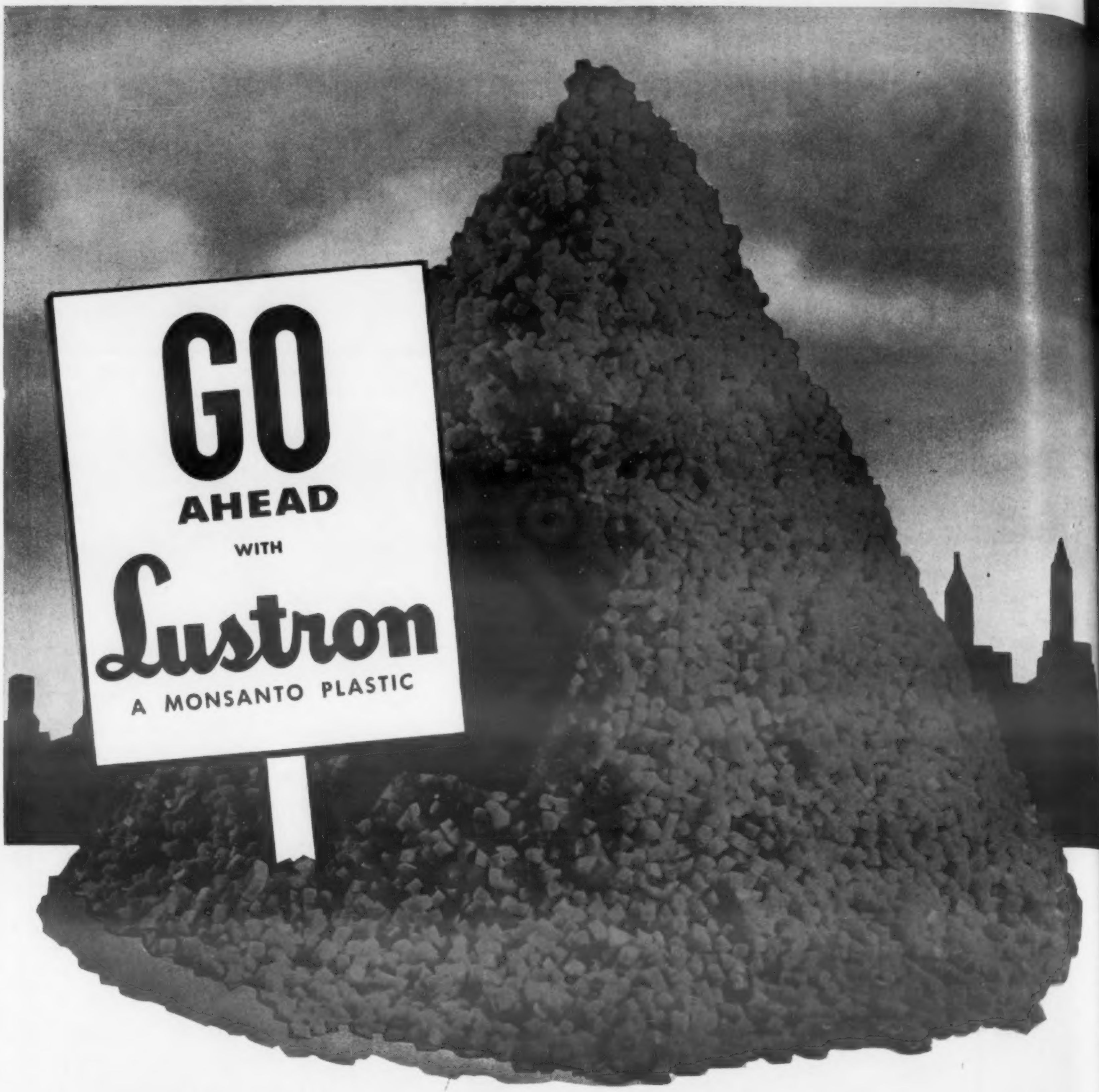
NUMBER 135
March, 1947

Hardness of Magnesium Alloys

MATERIALS: Magnesium Aluminum Alloys

Studies made in Great Britain upon a number of the magnesium alloys indicate that hardness of the metal in the as-cast condition, after solution treatment, and in the fully heat treated state is related to the aluminum content. Formulas constructed were based upon empirical data so that hardness of a given alloy may be predicted within limits of the range of compositions studied. The work was reported by J. L. Walker in *Magnesium Review*, Vol. 5, No. 2, 1945. Both cast and wrought alloys were studied. An interesting corollary is the fact that no relationship exists between hardness and tensile strength. The curve here given is plotted from a summary of the original data, and the formulas as in the original work. *Prepared by Kenneth Rose, Engineering Editor.*





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So plan to move ahead with full speed and certainty in '47. Specify Lustron in your product plans. You'll be safely out in front! Write for complete Lustron data . . . technical information, information on supplies: MONSANTO CHEMICAL COMPANY, Plastics Division, Springfield 2, Mass. In Canada, Monsanto Ltd., Montreal, Toronto, Vancouver. See Monsanto at the National Plastics Exhibition, May 6 through 10, Chicago, Ill. Lustron Reg. U. S. Pat. Off

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- Finest molding qualities
- Freedom from taste and odor

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SERVING INDUSTRY . . . WHICH SERVES MANKIND

ATERIALS & METHODS Engineering File Facts

NUMBER 136
March, 1947

MATERIALS: General

Thermal Properties of Materials

Material	Lb. Per Cu. Ft. at 60 F	(Solid) Specific Heat	Melting Point, Deg. F	Latent Heat Fusion	Specific Heat (Liquid)	Boiling Point, Deg. F	Latent Heat Vaporization
Aluminum	166.7	0.248	1214	169.1	0.252	3272	—
Antimony	422	0.054	1166	70.0	0.054	2624	—
Babbitt: 75 Pb, 15 Sb, 10 Sn	—	0.039	462	26.2	0.038	—	—
Babbitt: 84 Sn, 8 Sb, 8 Cu	—	0.071	464	34.1	0.063	—	—
Bakelite	—	0.30	—	—	—	—	—
Beryllium	113.8	—	2345	621.9	0.425	5036	—
Brass: 67 Cu, 33 Zn	528	0.105	1688	71.0	0.123	—	—
Brass: 85 Cu, 15 Zn	—	0.104	1877	84.4	0.116	—	—
Brass: 90 Cu, 10 Zn	—	0.104	1952	86.6	0.115	—	—
Bronze: 90 Cu, 10 Al	—	0.126	1922	98.6	0.125	—	—
Bronze: 90 Cu, 10 Sn	—	0.107	1850	84.2	0.106	—	—
Bronze: 80 Cu, 10 Zn, 10 Sn	534	0.095	1832	79.9	0.109	—	—
Cadmium	540	0.038	610	19.5	0.074	1412	409
Chromium	437	0.12	2822	57.1	—	4500	—
Copper	558	0.104	1982	90.8	0.111	4703	—
German Silver	—	—	0.109	1850	86.2	0.123	—
Iron	491	0.1162	2795	117	—	5430	—
Iron, Gray Cast	443	0.119	2330	41.7	—	—	—
Iron, White Cast	480	0.119	2000	59.5	—	—	—
Lead	711	0.032	621	9.9	0.032	3171	—
Magnesium	108.6	0.272	1204	83.7	0.266	—	—
Manganese	500	0.171	2246	65.9	0.192	—	—
Mercury	885	—	-38	5.1	0.033	675	117
Monel	550	0.129	2415	117.4	0.139	—	—
Nickel	556	0.134	2646	131.4	0.124	—	—
Nichrome	517	—	—	0.111	—	—	—
Platinum	1335	0.036	3224	49	0.032	7933	—
Resin—Phenol	80-100	0.3-0.4	—	—	—	—	—
Resin—Copals	68.6	0.39	300-680	—	—	—	—
Rubber	62-125	0.48	248	—	—	—	—
Silver	656	0.063	1761	46.8	0.070	3634	—
Solder: 50 Pb, 50 Sn	580	0.051	450	23	0.046	—	—
Solder: 63 Pb, 37 Sn	—	0.044	468	14.8	0.041	—	—
Tin	460	0.069	450	25.9	0.0545	4118	—
Zinc	443	0.107	786	47.9	0.146	1706	—
Zirconium	399	0.067	3100	—	—	9122	—
Low Melting Point Alloys:							
Lipowitz 26 Pb-13 Sn-10 Cd-51 Bi		0.041	140	17.2	0.041	—	—
Woods 26 Pb-13 Sn-12 Cd-49 Bi		0.041	158	17.2	0.042	—	—
Roses 28 Pb-25 Sn-50 Bi		0.043	230	18.3	0.041	—	—

Adapted from information supplied by Industrial Div., Bryant Heater Co., Cleveland, Ohio

MATERIALS & METHODS DIGEST

A selective condensation of articles — presenting new developments and ideas in materials and their processing — from foreign journals and domestic publications of specialized circulation.

Edited by H. R. CLAUSER

New Uses for High Tensile Alloy Steel Castings

Condensed from "Foundry Trade Journal"

The recent war has seen an evolution of high tensile alloy steel castings parallel to that of alloy steel forgings in the first World War and, as a result, many new engineering uses are possible. The engineer should bear in mind that castings offer the following essential characteristics: a range of mechanical properties directly comparable with that given by steel forgings; freedom from directional properties; flexibility of design giving weight saving; weldability; minor design changes readily introduced; and machinability equal to and usually better than forged steel of equivalent hardness.

Steel making practice is essentially the same whether making high quality steel for ingots or castings, but as war production clearly brought out, heat treatment is necessary to develop the full potential properties of alloy steel castings. Also, since it is of little use producing castings with unusually high nominal tensile properties if the castings themselves are unsound, it is now normal practice to X-ray pilot castings and to adjust methods of running and feeding until consistent soundness results. Gamma radiation is used for sections over 4 in. Magnetic and fluorescent crack detection apparatus is available to supplement X-ray inspection. Supersonic methods of internal flaw detection have not met with success as far as steel castings are concerned.

The cement-sand (Randupson) process has gone far towards eliminating the human element, and it gives a molding technique yielding castings with a high degree of uniformity of quality and dimensions. The important principle of making feeder heads and runners integral with the pattern equipment is not necessarily confined to cement sand molding. Of later years it has become possible to apply centrifugal casting to parts that are not annular rings or cylindrical in shape—a development which is of great importance in view of the high degree of internal soundness of centrifugal castings.

An example of the successful use of steel castings during wartime was the earthquake bomb, cast of a 112,000 to 123,200 psi. tensile strength 3% chromium-molybdenum steel. One of the largest tonnage applications of high tensile strength steel castings was in the field of tank and armored car production. At first, oil hardened 3% nickel-chromium-molybdenum or air hardened 4% nickel-chromium-molybdenum steels were used to meet the ballistic test and a tensile strength of 134,400 to 156,800 psi. As the war progressed, there was a gradual reduction in alloy content, until it was finally possible to provide the same protection with steels of half the original alloy content.

During the war, large quantities of centrifugally cast wheel hubs were made, many of 1¼% chromium-molybdenum steel, generally heat treated to 100,800 to 123,200 psi. The development of the past years in general steel foundry technique ultimately made steel castings of aircraft quality possible.

The advent of high tensile steel castings has been of considerable importance in the field of gears. Although the cost of alloy steel gear blanks may be almost the same as that of carbon steel gears, the substitution of the higher tensile material allows the designer to reduce considerably the size of the component parts of the complete gear unit. (J. F. B. Jackson. *Foundry Trade J.*, Vol. 80, Sept. 26, 1946, pp. 83-89.)

Practical Aspects of the Interrupted Quench

Condensed from a Paper of the American Society for Metals

The generally recognized advantages of martempering as applied to treatment of low and medium carbon alloy steels may also be obtained with steels of the higher carbon types. The practical advantages of this process is that less deformation will be encountered by taking advantage of the interrupted quench, and, therefore, the finished parts should contain less unbalanced residual stresses, so that premature failures should be fewer.

Early work by the author proved that alloy steels of the carburizing types could be martempered not only with less deformation, less retained austenite and with cleaner surfaces, but also that the process was much cheaper, since a long diffusion cycle after gas carburizing as well as difficult cleaning operations could be eliminated. It was also found that the process could be applied successfully to medium carbon alloy types, such as SAE 4140 and 6150.

However, difficulty was encountered with the higher carbon low alloy steels such as SAE 52100. Through subsequent work it was learned that to successfully martemper these steels it is absolutely necessary to have good equipment and careful control.

It was found that parts are less likely to crack if austenitized by oil-quenching. An atmosphere-controlled furnace or neutral salt bath is most satisfactory for the austenitizing operation prior to martempering. If an atmosphere-controlled furnace is used, it should possess good circulation, otherwise there may be portions which will overheat and eventually lead to failure.

It is also recommended that anyone contemplating the installation of equipment for martempering the higher carbon steels should develop the process carefully in their own plant in order to avoid failures which might ordinarily be charged to some inherent weakness of martempering. (Howard E. Boyer. Paper, *Am. Soc. Metals,* Preprint No. 20, 18 pp.)

High- and Super-Speed Cutting of Metals

Condensed from "The Engineers' Digest"

As the quality of cutting alloys improves and machining operations tend towards finer cuts and feeds, metal research workers are beginning to consider cutting speeds running into many hundreds and even thousands of feet per min.

The basis of all super-speed cutting operations lies in softening the metal at the point of contact by heating it. The amount of this heating depends upon the work expended in the cutting operation. For all practical purposes the temperature rises steadily as the speed of cutting increases.

This tendency to speed up the cutting has

DIGEST

led to a search for heat-resisting cutting materials which permit working in temperature ranges where the metal is appreciably weakened. The use of new hard cutting alloys which can withstand temperatures of 1470 to 1660 F makes possible cutting speeds in some cases of many hundreds of feet per min. But these materials are brittle and cannot stand up to much vibration and impact.

The latest cutting alloys with increasing percentages of cobalt, tungsten and titanium are an improvement in the cutting of steel.

The problem of wear has been combated by new tool shapes designed to strengthen the tool, reduce abrasion and improve the flow of heat away from the tip.

High cutting speeds have found their best application in milling, particularly end or face milling. But the theoretical suppositions that speeds of several thousand feet per min. will be possible, based on consideration of plastic deformation alone, of which there has been a great deal of talk in America around 1944, have proved quite wrong in practice. At 3000 to 6000 ft. per min. the metal removed simply burns and the tool life is negligible.

As a result, speeds of several thousand feet per min. are for the moment out of he question, except in the case of aluminum. Cutting speeds of over 5000 ft. per min. have been recorded for aluminum. In steel, considerations of tool life limit the speed to 500 and 800 ft. per min.

Thus, the problem for the moment is that of fully utilizing the threefold increase of speed which the high-speed alloys theoretically justify. (I. M. Besprozvany, A. N. Danielian, A. V. Pankin & N. I. Reznikov. *Engineers' Digest,* Vol. 7, Nov. 1946, pp. 361-363.)

Variable Section Tubes and Shapes in Light Metal Parts

Condensed from "Revue de l'Aluminium"

Often, in design of parts, particularly for bending loads, the rational determination of the required section leads to the idea of solids of equal strength. In such parts, the maximum fatigue stress is substantially the same in the different sections. The result is a maximum utilization of the material, as well as economy, weight saving and better appearance. These qualities are particularly desirable in many applications of light alloys. Sometimes this solution leads to very elastic parts where the designer has to augment the rigidity by stiffeners or by the use of a material with a higher elastic limit.

In airplanes this type of design led first to assemblies composed of constant section shapes made from strip or sheet. This method of construction is not quite the equivalent of a solid of equal strength when relatively heavy shapes are involved. Therefore, machining has been used to give long lengths of large shapes the desired form. This machining is a tedious operation which requires an easily machinable material and which wastes considerable material in the form of chips.

In order to simplify the work of the manufacturer, the fabricators of light alloys have attempted to produce products with variable section. Various means of fabrication of variable section tubes and shapes include rolling, drawing, forging, pressing, tube reducing, and staving. Where an increase in the elastic limit, at the expense of elongation, is desired, the formed parts may be heat treated. This heat treatment may be followed by straightening to compensate for the deformation in the quench.

The producers of semi-finished products of light alloys are actually equipped to fabricate a sufficiently wide range of variable section products to permit manufacturers to make constructions which are simultaneously light and strong and have a good appearance. However, each application raises a special problem in fabrication, the best solution to which can be found in close collaboration between the supplier and the consumer. (Pierre Petrequin. *Revue de l'Aluminium,* Vol. 23, Oct. 1946, pp. 310-314.)

Ferritic Disks Used for Gas Turbines

Condensed from "Metallurgia"

The advantages of the ferritic turbine disks used in the De Havilland gas turbines are: (1) proof stresses (0.1% strain) of 89,600 to 123,200 psi. at temperatures below 660 F can be obtained by hardening and tempering; (2) the thermal expansion coefficient is low, so thermal stress effects are reduced; (3) forging, machinability and heat treatment present no special difficulties; (4) reproducibility of sound forgings is comparatively easy; and (5) low alloy steels are attractive economically.

The disadvantages, as compared with austenitic steels, are: (1) the creep strength of most steels falls rapidly at temperatures over 1020 F; (2) notch sensitivity is generally greater at temperatures under 750 F; and (3) weldability is poor. Nearly all the disadvantages can be avoided by preventing overheating of the rim adjacent to the buckets.

The properties and compositions of four well-known Jessop steels are listed in the table below.

For very highly stressed disks operating at the highest temperatures, the first choice would be H.40, which is similar to the steel used in the German Junkers Jumo 004 jet engine. This steel is also notably free from notch sensitiveness in alternating stress fatigue and is the only one of the four recommended for welding. If the temperatures at the roots of the buckets are nearer 930 F, the next selection would be H.27 or H.30. H.3A is not expected to be the best compromise for future turbines in which working temperatures are being increased.

Turbine disks up to 30-in. dia. and 6-in. thick have been produced. Many precautions have to be taken in steel making and casting pit practice to give a dense structure, free from major segregation, gas porosity and hair-line cracks. (D. A. Oliver & G. T. Harris. *Metallurgia,* Vol. 34, Oct. 1946, pp. 293-295.)

Jessop Brand	H.3A	H.27	H.31	H.40
Composition				
%C	0.6	0.4	0.4	0.25
%Mn	0.5	0.6	0.4	0.4
%Si	1.2	0.3	0.3	0.4
%Cr	6.0	3.0	1.1	3.0
%Mo	0.5	0.8	0.7	0.5
%W	—	—	—	0.5
%V	—	0.2	—	0.75
Treatment				
oil quench from (F)	1800	1760	1580	1940
temper at (F)	1365	1200	1165	1240
Room Temperature Properties				
0.1% proof stress, psi.	100,800	112,000	96,320	112,000
tensile strength, psi.	134,400	134,400	129,920	134,400
elongation, % in L = 4 A	20	18	20	18
reduction of area, %	40	40	40	45
Creep Strength, psi. for 1% Strain in 300 hr.				
930 F	24,640	49,280	64,960	58,240
1020 F	11,870	28,000	35,840	47,040
1110 F	6,270	12,320	14,110	30,240
1200 F	—	—	—	14,560

Pipe Electroplated Inside for Corrosion Resistance

Condensed from "Corrosion and Material Protection"

A method known as Lectro-Clad has been developed by the Bart Organization for applying a corrosion resistant surface to ordinary low carbon steel pipe and tubing. The process electrolytically deposits a predetermined thickness of nickel or other corrosion resistant metals, on the inside surface of pipe, tubing and fittings. It develops a smooth, ductile, pore-free deposit in thicknesses of from 0.005 to 0.100 in.

Lectro-Clad pipe can be flame cut, welded and fabricated similar to low carbon steel pipe. Bending can be performed successfully, hot or cold, within ordinary limits of minimum recommended radii. These opera-

(Continued on page 127)

DIGEST

tions are possible because the electrodeposited nickel becomes an integral part of the base metal; consequently, there is no peeling or cracking when heat is applied.

One of the significant characteristics of the process is the smooth deposit obtained. Depressions present in the steel are more heavily coated than high spots, thus tending to even the electrodeposited surface. Generally in electrodeposition, high points, which are closest to the anode, receive more deposit. It is believed that the reverse of this occurs in the Lectro-Clad process because of the high current density, which is of the order of 200 to 250 amp. per sq. ft. Thus, the high points of closest proximity to the anode become polarized, thereby decreasing the efficiency and causing less nickel to be applied at these points.

Lectro-Clad tubing can be upset for a lap without affecting the applied metal on the internal surface. This enables the fabricator to produce flange joints, gasketed with full face gaskets, and obtain protection against corrosion. Another method of obtaining a lap joint, without upsetting the pipe, is to weld lap nipples already clad with corrosion resistant material, to mill lengths of the pipe. Fittings and other pipe line accessories can be similarly processed. (S. G. Bart. *Corrosion & Material Protection,* Vol. 3, Oct.-Dec. 1946, pp. 8-10.)

"Press-Welding" Aluminum for Aircraft Radiators

Condensed from a Report by the Joint Intelligence Objectives Agency

A novel method of welding and forming aluminum sheet was used by the Germans during the war in the manufacture of aircraft radiators. In the operation, sheets of aluminum are virtually melted together between gas heated dies that are closed under pressure. When the dies are nearly closed, compressed air is injected between the sheets to blow open the areas between the rows of welds, in order to form passageways conforming to the design of the dies.

In one particular application, the gas fired dies were about 3 ft. long, 2 ft. deep, and 2½ ft. high. The gas regulator and gage unit (of angle iron construction) was about 1½ ft. long, 3 ft. deep, and 6 ft. high.

The resultant pieces, welded and formed by this method, were hand welded together, to produce the finished aircraft radiators.

The working temperature of the press welder is 842 F. The air pressure of the air cushion in the machine table is 36.8 to 51.5 psi., and the pressure of air used to blow open the sheets is 265 to 350 psi. The air pressures selected depend upon the physical properties of the material, and only after experimentation can another material be employed. (T. G. Haertel. Report No. 417 of *Joint Intelligence Objectives Agency,* 12 pp.)

Rapid Method Determines Conditions for Electrolytic Polishing

Condensed from "Metaux et Corrosion"

In the past, a large number of formulae for electrolytic polishing of metals have been published. Since so many variables are involved, however, it is still necessary to make tests in each case to determine the exact procedure.

A method is proposed which makes it possible to obtain, by means of a single test, qualitative information on the conditions necessary for electrolytic polishing a given metal or alloy. The anode of the metal to be polished is inserted between cathodes in a beaker of the solution to be tested. Part of the anode is shielded by a glass tube or cylinder to subject the anode to a variable current density ranging from very high on the exposed end to very low on the shielded end. The appearance of the anode after a brief electrolytic treatment indicates the suitability of the electrolyte and approximately the current density required for a brilliant polish. The range of current density that can be tolerated in polishing is shown by the width of the polished area on the anode.

With a slight modification, effect of polishing time can be taken into consideration. In this case the variation in current density is provided by a glass shield slit on one side. The electrolyte is added at a constant rate so the mutual effect of changes in current density and time on the degree of polishing can be observed. Numerical results can be obtained by the addition of mobile equipment for determining the contact potential, but only at the expense of simplicity. (Francois Bertein. *Metaux et Corrosion,* Vol. 21, Mar. 1946, pp. 40-43.)

Developments in Thorium, Uranium and Zirconium

Condensed from Papers of the "Electrochemical Society"

Special interest in rare metals such as zirconium, uranium and thorium started with the last war. These metals have one property in common: their oxides cannot be reduced in hydrogen, nor can they be prepared in pure form by reduction with carbon; also, they are not easily melted and cast on ordinary refractories.

Production of these metals in general involves three basic processes: (1) electrolysis of a suitable compound of the metal in a fused salt electrolyte, (2) reduction of a compound of the metal with the alkali or alkaline earth metals, and (3) thermal decomposition of a volatile compound of the metal on a heated wire or filament. Since these metals have high melting points they are produced by methods 1 and 2 as metal powders which may be pressed and sintered into solid compacts or in some cases melted on a suitable refractory.

DIGEST

Thorium metal is very soft with a Vickers hardness of about 100. A freshly prepared surface is bright, but this becomes coated with a film of oxide which protects the metal from further attack. The density of the sintered metal is approximately 11.3 and the melted metal, 11.5. It may be cold rolled into wire or sheet, and with highly finished rolls, sheet will remain relatively bright for some period of time in air, maintaining a high lustre. It may be cold swaged, but it is not readily adaptable to cold drawing because of its relatively low tensile strength.

Zirconium compacts have been produced with a hardness of Vickers 183; it can be easily machined, tapped, and drilled. Melted zirconium has been produced which is harder than sintered zirconium; it can also be machined, tapped and drilled.

Both uranium and thorium have been employed in photo-electric cells to detect and measure limited portions of the violet or ultraviolet spectrum. Zirconium has been repeatedly suggested and used as a getter or a gas clean-up agent in various vacuum and gas filled devices. (J. W. Marden, W. C. Lilliendahl & D. M. Wroughton. Papers, *Electrochemical Soc.*, Part I, 3 pp., Part II, 6 pp., Part III, 4 pp.)

Fatigue Tests as Criterion of the Weldability of Sheet

Condensed from "Institut Technique du Batiment et des Travaux Publics"

A previous report on carbon steel had demonstrated the superiority of fatigue tests over static tests as a criterion of weldability of sheet, so analogous tests were made on chromium-molybdenum steel containing 0.17 carbon, 0.45 manganese, 1.05 chromium, 0.34 molybdenum and 0.32% nickel. Tensile and fatigue tests were made on the sheet as furnished and after welding with a mild steel rod. The results were evaluated statistically. The mean tensile strength as welded was 90% of that of the parent metal, the elastic limit 95%, the elongation 35%, and the endurance limit in repeated bending 73%.

Chemical analyses, macroscopic and macroscopic examination indicated the sheet was homogeneous. The micrographic examination of the welded sheet showed a Widmanstätten structure in the fusion zone, upper bainite in the hardened zone, and a spheroidized structure with traces of acicular ferrite in the next zone, while the parent metal was composed of ferrite, acicular ferrite, and fine lamellar pearlite. Rockwell hardness tests gave a hardness corresponding to 140 Brinell in the fusion zone, about 225 Brinell in the hardened zone, about 160 Brinell in the adjacent tempered zone,

DIGEST

and about 195 Brinell in the parent metal. Failure in the tensile tests did not occur in the tempered but in the hardened zone.

It was possible to establish a certain, tentative correlation between surface finish and the endurance limit. The specimens with the best surface had the highest endurance limit, although the reverse did not apply. If this fact is confirmed in further tests, the determination of surface finish might supersede fatigue tests as a control test for sheet. (R. L'Hermite, D. Seferian & F. Canac. *Inst. Tech. du Batiment et des Travaux Publics,* Circulaire, Series G, No. 14, Oct. 15, 1946, 28 pp.)

Wood-to-Metal Adhesives

Condensed from a Paper of the "American Society of Mechanical Engineers"

The evolution in wood-to-metal adhesives is gaining momentum in the manufacturing industries through the introduction of new resin adhesives. These are replacing the casein-latex combinations which have certain limitations, chiefly in ultimate durability under severe exposures.

Three outstanding advantages developed in hot-pressed resin adhesives for wood-to-metal gluing are: (1) extreme durability, (2) major reductions in time, equipment and room, and (3) slight compression to equalize uneven thicknesses together with partial resin penetration into the wood.

An outstanding use of metal-to-wood adhesives is in the production of large sheets. The general term plymetal is applied to this product. It consists of layers of metal and sheets of veneer arranged in various ways to suit particular applications. Plymetal combines the good characteristics in metals, such as high density, surface hardness and strength with the lightness, moderate cost and excellent stiffness factors in wood.

There are several procedures for metal-to-wood bonding. One of these employs a standard metal-to-metal adhesive on the metal side of the joint and a compatible wood adhesive on the mating side. The coated surfaces are brought together under heat and pressure. In another procedure the adhesives are first heat cured on the metal and then bonded to the wood layer with room-temperature adhesives. Another procedure uses metal-to-wood adhesive in film form. The film is interleaved between the sheets or layers and then pressed. This is the simplest and cheapest type of wood-to-metal bond where volume is sufficient to warrant the necessary equipment, such as annealing ovens, conveyors, and hot press.

The list of applications for materials such as plymetal is impressive. In the transportation industries plymetal is used for floors, walls and roofs in trucks and buses,

DIGEST

and for many parts in railroad cars. In aircraft, aluminum alloy—plywood constructions have proved their worth. Other applications include interior building partitions, table-tops, kitchen equipment, hospital equipment and tool handles. (Thomas D. Perry. Paper, *Am. Soc. Mech. Engrs.*, Dec. 1946 meeting, No. 46-A-13, 6 pp.)

Gas Annealing Developed for Whiteheart Malleable Castings

Condensed from "Foundry Trade Journal"

It has long been realized that the present method of annealing whiteheart malleable by packing in ore in heavy cans is inefficient. A radically new gaseous annealing method has been developed which eliminates the cans and ore and reduces the annealing time from several days to 20 to 30 hr. Other advantages are: reduction in labor requirements, reduced floor space for a given output, considerable saving in operating costs, improved cleanliness and better working conditions, and improved quality and uniformity of product.

Since the fundamental process of whiteheart annealing is decarburization, the atmosphere should have a $CO:CO_2$ ratio of 3 to 10:1 and an $H:H_2O$ ratio of 1½ to 5:1 for the temperature range 1740 to 1920 F. To keep the rate of decarburization at a maximum, fresh supplies of the proper atmosphere must be introduced continually. This may be done by supplying fresh gas or by regenerating and recirculating the spent gas. Recirculation is most desirable from an economic point of view. An air or steam generated system appears to be the obvious choice; the former is simpler to supply.

The prime requirement of the furnace is a relatively gas tight annealing chamber. Muffle furnaces are not practical so electric or radiant tube heating are used. To prevent oxidizing on cooling, provision must be made for cooling the annealed charge to 1020 to 1110 F before discharging. A typical batch furnace is described which is suitable for blackheart as well as for whiteheart annealing, although the blackheart requires a non-decarburizing atmosphere and closer control of the cooling cycle.

No continuous furnace for gaseous annealing of whiteheart castings has yet been installed, but a type similar to that used in the U.S.A. for blackheart castings would be satisfactory with suitable changes in the temperature cycle and atmosphere. A large continuous furnace would apparently have a slight cost advantage but the batch furnace is more flexible and is to be preferred for small or varied outputs. (P. F. Hancock. *Foundry Trade J.*, Vol. 80, Nov. 29, 1946, pp. 309-316.)

DIGEST

Passivating Treatment Improves Cadmium Plate Coatings

Condensed from "Metallurgia"

Cadmium as an electroplate coating has long been recognized as having protective qualities competitive with zinc, but the supply of cadmium is limited and the cost high. During the war cadmium plating receded to very small proportions but today its more general adoption becomes possible. Cadmium is a sacrificial protection for iron and steel. It is the preferred finish for steel in the radio industry.

Cadmium is not normally used on brass and copper because the latter are so highly electronegative in relation to the cadmium that a heavy non-porous coating is essential. However, in many industries, the assembly of a variety of components leads to numerous bimetallic junctions which tend to promote corrosion due to local cells being set up under damp conditions. This risk is minimized by reducing the electrochemical dissimilarity at the junctions by electroplating. Thus, it is often useful to cadmium plate copper and other nonferrous alloys that have to be assembled to cadmium plated steel.

One of the shortcomings of zinc coatings is their propensity to form white corrosion products. This deterioration can be eliminated or greatly retarded by passivation in an aqueous chromate solution. Cadmium coatings are usually denser than zinc coatings but they fail in much the same way. The progress of corrosion is not quite the same, as it may be quite sudden with cadmium under humid conditions. However, exactly the same passivating treatment can be applied to electroplated coatings of cadmium as to those of zinc. The degree of added protection afforded by this treatment is even greater than that found with zinc.

The passivating solution normally comprises 150 to 200 grains sodium dichromate crystals and 5.5 to 10.0 ml. concentrated sulfuric acid per liter of water. An inhibitor is used to minimize attack on the cadmium.

Chromate passivation improves the serviceability of the cadmium coating out of all proportion to the effort and cost in its application. The solution is inexpensive and simple to maintain. It is only necessary to ensure that the work passes to the chromate solution direct from the plating process, to control the immersion time and to avoid overheating in drying the work. Hot water leaches inhibitive chemicals from the passive film and hot baking drives out combined moisture, both depreciating its value somewhat. (E. E. Halls. *Metallurgia*, Vol. 34, Oct. 1946, pp. 295-297.)

Engineering Shop Notes

Loading-Unloading Fixture for Presses

by Kenneth Rose, Engineering Editor,
MATERIALS & METHODS

A loading, positioning and unloading device for pressworking operations has been developed at the Fort Wayne plant of International Harvester Co. Extremely simple in operation, the mechanism makes the entire operation of the press automatic except for placing the parts in the fixture. The motion of the loading-unloading fixture is integrated with the operation of the press ram.

The device consists of a slotted circular disk, revolving horizontally about a center on the press table, and is so positioned as to bring the workpieces under the ram of the press at some station in the circle. The workpieces fit into slots in the disk. The motion of the disk is controlled to move the disk through a fraction of a revolution equal to the number of slots provided in the disk. Thus, a disk with 20 slots would be moved one-twentieth of a revolution at each stroke of the press.

The automatic positioning fixture for pressworking operations is adaptable to many different parts. (Courtesy: International Harvester Co.)

By this means each slot, with its accompanying workpiece, is brought under the ram in succession. The further motion of the disk carries the finished piece to the discharge station, where it falls into a chute and is carried to a tote box.

The revolving disk can be loaded at any of the stations between discharge and pressworking, giving the operator a certain degree of freedom. A flat stationary disk under the revolving disk backs up the piece until it reaches the discharge station, where an open segment permits the finished piece to fall through the slot and into the chute. At the station directly under the ram a more solid backing is provided, corresponding to the lower die.

In the operation shown in the accompanying illustration, connecting rods are being straightened and coined. The rod is straightened and both ends are pressed to size in this operation. While the ends are faced off later, the coining saves rough machining the piece. This disk contains about 20 slots. The rotary motion is imparted to the disk by a pawl, working in a horizontal plane, and operating against notches in the periphery of the moving disk as a ratchet wheel. The pawl in turn is actuated by the ram of the press.

Interchangeable disks make the press feeding device adaptable to the handling of many different parts. Rocker arms, shackles, wheel nuts, steering arms, etc., are worked on this press, a 100-ton toggle type, using a properly slotted disk for each different kind of part. The pawl is adjustable, so that it need not be replaced with the change of disks.

An added feature of the loading-unloading device is that it provides greater safety for the workman. The disk is loaded at one of the stations at the front of the press, well out of the way of the ram. Unloading takes place automatically, so that there is no occasion for the operator to reach into the working zone of the press.

Special Tool Designed for Reaming Punches

by Robert Mawson

A machine shop recently developed a rather novel and interesting machining method to manufacture a quantity of punches made of tungsten steel. These were 2½-in. in dia., about 3-in. long and had a ½-in. hole drilled and reamed the entire length. The specifications called for the hole to be perfectly straight and with no tool marks.

The shop first tried to do the job in a lathe, feeding the reamer by power or by hand, but the hole was rough and far from satisfactory. A vertical drill press was then tried, but with no better results. Even when the operator fed the reamer by hand the travel could not be controlled and the finished hole had tool marks and a rough surface.

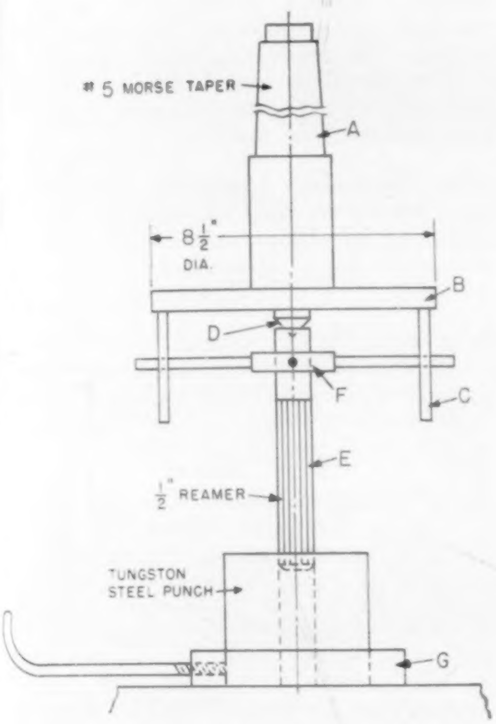
The problem was solved by designing the tool here described. This tool was made with a No. 5 Morse taper shank, marked "A" in the sketch, to fit the spindle of a vertical drill press. At the lower end of the shank was a round disk 8½-in. in dia. and fastened in this disk were two steel pins "C" ½-in. in dia. by 3¼-in. long. A locating center "D" was provided, suitably ground to center on a ½-in. reamer "E."

(Continued on page 133)

A feed weight "F" was provided which could be attached to the reamer with a setscrew. The punch to be reamed was held in a centering ring "G" which, in turn, was clamped to the drill press table.

To perform the reaming operation, the punch was fastened in the ring as shown and the drill press started in operation without feed. The feed was provided by means of the weight "F," which carried down the reamer as metal was removed. It was found by experiment that a feed weight of 28 lb. gave perfect results for this size of hole and in this grade of steel.

With this method the operation does not depend on the judgment of the man to feed the reamer at the proper speed, because the weight feeds down to suit the metal which is removed.



Sketch of the special tool for reaming punches.

High Nickel-Chromium Alloys Increase Thermocouple Life

by E. A. Murphy, Brown Instrument Co., Div. of Minneapolis-Honeywell Regulator Co.

A good thermocouple tube must possess many desirable characteristics. At elevated temperatures, it must prevent injurious gases from contacting the thermocouple; it must resist high temperature corrosion; mechanical strength must be high; time lag must be held low; its cost must not be excessive. The Brown Instrument Co. ran tests on various nickel-chromium alloys to find the one that had these desired characteristics. The alloys tested were: 80 nickel, 14 chromium, 6% iron; 60 nickel, 14 chromium, 26% iron; 32 nickel, 20 chromium, 48% iron; and 0 nickel, 28 chromium, 72% iron.

Combining all of these qualities with ready availability, Inconel protecting tube (80 nickel, 14 chromium, 6% iron) proved to meet all the demands for uninterrupted temperature measurement.

The atmospheres most commonly found in industrial heating furnaces may be classed as oxidizing, reducing, alternately oxidizing and reducing, and sulfurous. This alloy does not scale in air below 2000 F, whereas the other alloys scaled at temperatures above 1900 F.

In reducing atmospheres, or those which are alternately reducing and oxidizing, the resistance to corrosion increases with the amount of nickel present in the alloy. The 80% nickel alloy proved itself more resistant to this form of corrosion than the others tested.

Since gases containing sulfur compounds are highly corrosive to nickel, this alloy is not recommended were sulfurous gas content of the atmosphere exceeds 1%. This appears to be the single exception in which nickel fails to prove superior.

Sagging of a protecting tube, mounted horizontally, is highly undesirable and, in some cases, can result in the measurement of non-representative temperatures. In most steel-jacketed furnaces, a protecting tube which has sagged is extremely difficult to remove for replacement. The 80 nickel-14 chromium alloy, when extending horizontally inside a furnace for 24 in., will not sag at temperatures below 1800 F.

A thermocouple actuated instrument controlling a process is no more responsive or sensitive to temperature changes than its primary measuring element. It follows naturally that protecting tubes having high time lags contribute much to the complexities of automatic control problems. The tests showed that the time lag of the Inconel protecting tube was in general less than the other alloys tested.

Thus, it seems that for the majority of industrial furnace applications below 2000 F, Inconel protecting tubes, because of their outstanding characteristics, high mechanical strength, and more rapid thermal response, offer advantages over other tubes. They make good "general-purpose" tubes for all applications where the sulfurous gas content lies below 1%. Where the sulfur content exceeds this value, the use of a nickel-free alloy such as 28% chromium-iron provides excellent service life.

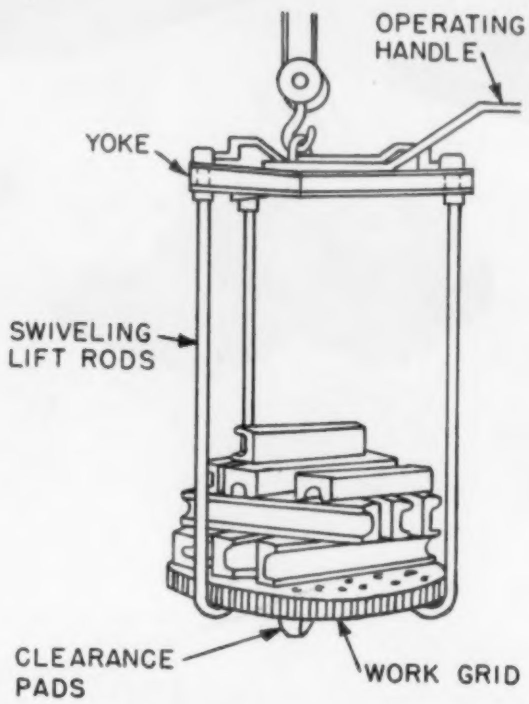
By standardizing on Inconel, it is possible to reduce materially the stock of various kinds of protecting tubes normally carried by most plants; a factor in holding operating costs to a minimum.

Fixture for Handling Work in Heat Treat Furnace

by Stanley Lapinski, Pelton Steel Castings Co.

For more efficient handling of steel castings during heat treating operations we have devised a special "swivel" fixture which facilitates loading and unloading parts in the furnace. It has proved successful for us and may be of help to other heat treaters.

Loading and unloading is handled on the fixture as shown in the sketch. The fixture consists of a yoke provided with a



Sketch of the "swivel" fixture with the swiveling lift-rods engaged.

special handle that controls the revolution of the swiveling lift-rods. The lower or grid end of these lift-rods are bent to a 90-deg. angle or hook, so that they will fit under the grid. As can be seen in the sketch, the grid has clearance pads on the underside which provide clearance for the movement of the hook part on the lift-rods.

The complete fixture carrying the work load can be lowered into the furnace work chamber by means of an overhead crane or hoist, and the lifting yoke and swiveling lift-rods disengaged, and removed. Thus, only the grid and actual work-load remain in the furnace. This, of course, eliminates the necessity of heating and quenching the yoke and lift-rods.

Advantages are four-fold: (1) Quenching wear and tear on yoke and lift-rods is eliminated, making it possible to construct these parts of inexpensive structural steel instead of costly alloy; (2) fuel consumption is reduced, as it is not necessary to bring the yoke and lift-rods up to heat; (3) speed of heating is increased as charge reaches quenching temperature quicker when it is not necessary to heat yoke and lift-rods; and (4) conditions for the heat treater are improved. It is not necessary for him to be near to, or look into the furnace work chamber. By merely giving the special handle a push (it's quite long—about 5 ft.), he disengages the lift-rods and yoke, and the crane lifts it out of the work chamber.

Cold weather is especially conductive to goggle fogging. A simple means to prevent this is to cut a sliver from a bar of ordinary yellow soap and rub it lightly over the inside of the lenses, then polish the lenses thoroughly. If the polishing is done properly, the soap will not distort or reduce vision and it will keep the inside of the lenses clear.

MANUFACTURERS

Materials

Springs. A new edition of the *Accurate Spring Mfg. Co.'s* handbook on springs contains technical data on design formulation, load deflection, specifying springs, etc. Numerous illustrations are included in this 36-page handbook. (1)

Cemented Carbides. A useful comparison chart of cemented carbide grades, offered by the *Adamis Carbide Corp.*, shows the range of cemented carbide grades produced, the designed application of each, materials to be used, etc. (2)

Special Steels in Motion Pictures. A 6-page, illustrated leaflet describes seven technical films on special steels that are available, free of charge, from *Allegheny-Ludlum Steel Corp.* for showing in office, plant or classroom. (3)

Plastics. This 4-page bulletin offered by *American Cyanamid Co.* discusses Urac Resin 110, a pure, white, dry urea-formaldehyde resin, with Hardener C-110-S for cold pressing with cereal flour extension. (4)

Copper. A comprehensive, 50-page catalog published by the *American Metal Co., Ltd.* presents complete data on OFHC copper, an oxygen-free, high conductivity copper. Numerous charts and tables are included. (5)

Aluminum Bronze Castings. Ten outstanding benefits derived by users through the use of Ampco Metal centrifugal castings are presented in a 4-page, illustrated bulletin, No. 53A, offered by *Ampco Metal, Inc.* (6)

Plastics and Coatings. A group of single-page and 4-page bulletins issued by *Calresin Corp.* discuss a variety of plastics and coatings, and includes prices, applications, physical properties, etc. (7)

Transparent Film. Lumarith, a Celanese plastic transparent film for packaging and other purposes, is featured in an attractive, 8-page, illustrated bulletin offered by *Celanese Corp. of America.* Physical and mechanical data are included. (8)

Stainless Steels. The type analyses, physical, electrical and mechanical properties, heat treatment, hardness, heat resistance, and working of a complete line of Rezistal stainless steels are all compiled into one table in folder form by the *Crucible Steel Co. of America.* (9)

Silicones. A complete list of DC silicon compounds, greases, fluids, varnishes, resins, etc., and their physical properties, is presented in a 12-page, illustrated bulletin published by *Dow Corning Corp.* (10)

Corrosion-Resisting Equipment. The composition and applications of Duriron, Durichlor, Durimet and Chlorimet, and the facilities for producing the equipment made with these corrosion resisting alloys, are presented in a 20-page, illustrated bulletin, No. H, of the *Duriron Co., Inc.* (11)

Insulating Varnishes. Complete technical and application data on 36 grades of G-E insulating varnishes are presented in a 40-page catalog, No. CDR-13, offered by *General Electric Co.* (12)

Laminated Plastic Gears. How to make gears with Lamicoid—sheets, tubes and rods made of laminated phenolic plastic that is thermosetting—is explained by *Mica Insulator Co.* in a 16-page booklet. (13)

Molded Plastics. The general properties and uses for molded plastics, as well as typical applications, are all compiled into a 2-page materials table offered by *Shaw Insulator Co.* (14)

Plastics. Complete data on Synthane, a laminated phenolic plastic, including typical applications, are presented by *Synthane Corp.*, in a 16-page, illustrated bulletin. (15)

Methods and Equipment

Air-Hydraulic Presses. The many features, uses, models and specifications of various air-hydraulic presses, produced by *Air-Hydraulics, Inc.*, are presented in an 8-page, illustrated bulletin. (16)

Electronic Heater. A new electronic heater that offers electronic induction heating that is safe, simple and practical is described and illustrated in an 8-page bulletin, No. 14B6430A, of *Allis-Chalmers Mfg. Co.* Specifications are included. (17)

Alloy Electrodes. Complete technical data on a variety of alloy arc welding electrodes produced by *Alloy Rods Co.* are presented in a 40-page, illustrated catalog, No. 46-RS-5M. (18)

Rods and Fluxes. Complete data on the entire line of low-temperature welding and brazing rods and fluxes produced by *All-State Welding Alloys Co., Inc.* are presented in a 30-page, pocket-size booklet. (19)

Rust Proofing Aluminum. The rust proofing process for producing a protective, skin-like coating on aluminum and its alloys through the use of ACP Alodine coatings is described in a 4-page, illustrated bulletin, No. 7-16-100, offered by *American Chemical Paint Co.* (20)

Temperature Control. Over 30 different application data sheets on automatic temperature control operations are listed on a mailing card, those bulletins desired to be checked, and the card returned to *Automatic Temperature Control Co., Inc.* (21)

Paint Spray Equipment. Black Arrow paint spray equipment, featuring the hollow air atomizer head for faster, easier production of perfect spray patterns, is described and illustrated in an 8-page bulletin, No. B-45-C, offered by *Black Manufacturing Co.* (22)

Industrial Refrigeration. A Bowser-Kold-Hold mechanically refrigerated unit for testing and processing at temperatures of −150 F is described and illustrated in a 4-page bulletin offered by *Bowser, Inc.* Specifications of two models are included. (23)

Bright Nickel Process. Lustrebright, a bright nickel process which, when added to cold nickel solutions, eliminates color buffing, re-cleaning and re-racking, and produces an ideal base for chromium, is discussed in a 4-page, illustrated, pocket-size booklet of *W. C. Brate Co.* (24)

Singeing Unit. This 2-page bulletin, No. 106, describes and illustrates the Carbomatic Singér, a fully automatic, infra-red singeing unit that requires only one pass through the singér to process both sides simultaneously. *Carbomatic Corp.* (25)

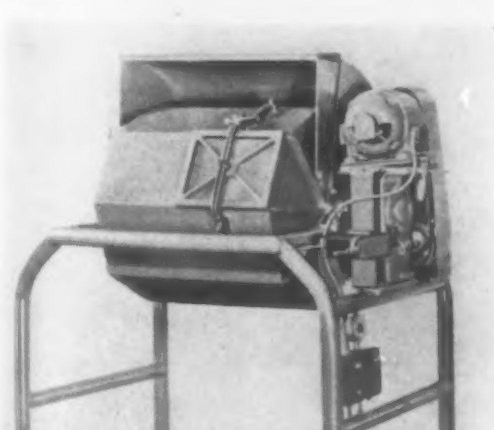
Surface Hardening Steels. This 4-page, illustrated bulletin published by *Chapman Valve Mfg. Co.* discusses Malcomizing, a process

New Materials and Equipment

Deburring and Finishing Barrels Have 4-Speed Drive

A line of 11 octagonal deburring and finishing barrels of 30-in. dia. and 32- to 60-in. length, with 9 standard compartment sizes from 12- to 60-in. length has been announced by *Almco Inc.*, 231 E. Clark St., Albert Lea, Minn. Design features include 4-speed drive, quick-clamp doors and welded steel construction throughout.

These barrels are furnished either plain (unlined) or with full neoprene lining. They are motor-driven at 10, 15, 20 or 30 rpm. (approx.) through a speed reducer and 4-step V-belt pulleys, a lever-operated belt release mechanism. To facilitate positioning of the barrel for loading and unloading, rotation in both directions is controlled by a start-stop lever which applies a hydraulic brake when in the "stop" position.



This deburring and finishing barrel is one of a line of 11 recently announced by Almco Inc.

The compartment doors are light in weight (21¼ lb. each for 16-in. compartment), and are opened and closed by a quick-acting toggle clamp. The clamping lever permits the door to be cracked open for draining before unloading. All doors have a water-tight sponge rubber seal, with a take-up adjustment to compensate for eventual compression of the seal. For rapid and complete unloading, door openings come within ¾ in. of the compartment end walls.

All barrels are mounted in a welded tubular steel frame, giving free excess to the doors for loading. To permit unloading directly into a work pan or onto a screen, there is 28-in. clearance beneath the barrel. The barrel itself has an approved guard rail and pull-down safety hood, and the driving mechanism is fully enclosed to meet all safety requirements.

New Porcelains Have High Strength at Elevated Temperatures

New all-crystalline porcelains, having high mechanical and dielectric strength at temperatures extending up to 2000 F, have been developed in the *Porcelain & Pottery Laboratory, National Bureau of Standards*, Washington, D. C. Such porcelains are particularly valuable for sustaining loads at elevated temperatures, as electrical insulators at elevated temperatures, and as insulators for such special applications as aviation spark plugs and radar transformers.

The composition of these new porcelains is characterized by the use of such materials as alumina, beryllia, zirconia, and thoria, with minor additions of other metallic oxides, and by the absence of silica. A representative high-beryllia porcelain contains 84 beryllia and 8% zirconia, with small amounts of lime and alumina; a typical high-zirconia composition is 80 zirconia, 10 beryllia and 10% magnesia.

The usual porcelain composition includes feldspar, which reacts as a flux with clay and silica, dissolving them in part to produce a viscous liquid. The liquid fills the interstices between the crystalline phases of the mixture, and upon cooling becomes a matrix of glass upon which the strength of the porcelain is largely dependent. This glass will soften and deform under stress at temperatures much lower than the temperatures at which the crystalline phases liquify.

Tests show that all of these new porcelains are very resistant to deformation or creep at temperatures up to 1800 F for long periods of time. A typical specimen, for example, showed an elongation of 0.23% after a total of 2600 hr., during which the applied stresses ranged from 9,000 to 14,000 lb. per sq. in. At temperatures of 1900 F and higher, however, the tendency to creep is more pronounced, and appreciably lower stresses produce a creep rate measurable by the hour.

Research and development are continuing in the field of high-temperature porcelains, for ceramics offer definite promise of usefulness in the high-temperature regions where metallic alloys are no longer serviceable.

World's Largest Steel Machinery Casting

The *United Engineering & Foundry Co.* of Pittsburgh, Pa., has completed what is reputedly the world's largest steel machinery casting. It weighs 472,000 lb. and is to be used as a frame for a 6,000-ton capacity, high-speed, mechanical forging press.

Four open hearth furnaces poured molten steel simultaneously into four ladles, which in turn were carried to the pit by overhead cranes. The 600,000-lb. main pouring was accomplished in 4⅓ min., after which 100,000 lb. of additional molten metal was poured at several intervals to make up for shrinkage. The casting was allowed to cool in sand for two months. The picture shows the last head being cut from the huge casting.

High Temperature Enamel Resists Chipping and Discoloration

A high temperature baking enamel, said to be non-chipping and non-yellowing, is being produced by *Naugatuck Chemical Div.* of *United States Rubber Co.*, New York 20. It can be applied on metal, glass and ceramics by such usual means as spraying, dipping or roller coating.

This organic surface coating, known as PQL, is supplied as a Xylol solution. Its applications range from light reflectors to Diesel motors. It is suitable on parts that operate at high temperature, such as hair dryers, and for kitchen and hospital equipment.

The recommended baking schedule is 20 to 25 min. at 400 F. The minimum temperature at which it can be cured is 375 F; at this temperature 60 min. is required to secure optimum properties.

This enamel retains its color up to almost 400 F, has a brilliant gloss, and is resistant to grease, all organic solvents, and salt spray.

A two-coat system utilizing a special primer is recommended for obtaining best mechanical characteristics (*i.e.,* maximum impact and chip resistance.) The primer can be applied directly over the metal, which requires no special preparation other than degreasing. If a one-coat system is used, the metal surface must be lightly sand- or grit-blasted.

Laboratory Furnace Operates Up to 2900 F

A new high temperature laboratory combustion furnace that can be used as a single, double or triple tube unit and having a maximum high operating range of 2900 F has been announced by the *Harry W. Dietert Co.*, 9330 Roselawn Ave., Detroit 4.

The furnace was designed for the industrial laboratory and comes as an integral unit, ready to plug into the 220-v. outlet, supplied complete with power supply, ammeter, rotary power selection switches, heating elements, automatic temperature control and thermocouple. A combination disconnect switch and circuit breaker is provided which automatically protects the furnace against overloads. An electronic automatic temperature controller is furnished so that the temperature of the furnace can be selected in advance and the temperature selected is automatically controlled.

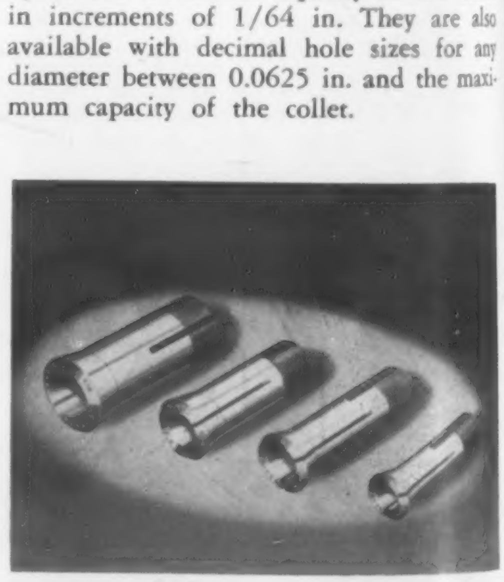
Six ¾-in. dia. heating elements are used which provide a radiating surface area of 128 sq. in. The interior of the furnace chamber is lined with insulating firebrick which will withstand a maximum temperature of 3000 F. The outer layer of insulating material is 1½-in. thick Super Block. The total furnace wall thickness is 6¼ in.

Brass Collets Give Good Service at Low Cost

A new line of draw-in collets made of brass instead of the usual hardened steel has been introduced by *South Bend Lathe Works,* South Bend 22, Ind. Although these brass collets are not intended to replace the hardened steel type, they are practical for many applications. Their low cost makes them especially desirable for odd sizes that are used only occasionally. With reasonable care they will give good service for short run production jobs.

When worn, a brass collet can be rebored to a larger diameter. Brass collets can also be bored for holding tapers or irregular shapes.

These collets are available in four types and are designed primarily for use with South Bend lathes. They are made in standard fractional sizes, 1/16-in. capacity up to the maximum capacity of the collet in increments of 1/64 in. They are also available with decimal hole sizes for any diameter between 0.0625 in. and the maximum capacity of the collet.



These brass draw-in collets, when worn, can be rebored to larger diameters.

Collets with metric hole sizes are supplied in increments of ½ mm., any size between 1.5 mm. and the maximum metric collet capacity. Brass collets are not made for square, hexagon, or other special shapes.

Drilling and Tapping Machine for Irregular Work Pieces

Designed primarily for drilling and tapping large copper anodes to receive hanging hooks, the *Cleveland Tapping Machine Co.*,

This horizontal drilling and tapping machine was designed primarily for processing large copper anodes to receive hanging hooks.

Hartville, Ohio, has developed a horizontal combination drilling and tapping machine incorporating features which make it suitable for a wide variety of applications in drilling and tapping long and irregular-shaped work pieces.

A hand control indexes the head for consecutively drilling and tapping, and the depth of hole and withdrawal of the tool are automatically controlled. A three-position indexing head can also be furnished to drill, countersink and tap the work-piece with one chucking.

An air operated vise for holding the work-piece is standard equipment. In the illustration, however, the air vise is mounted on a special table which functions as an air-operated cross-slide, positioning the work so that it may be drilled and tapped at a number of pre-determined points.

A work rest may be placed on the ways or on brackets fastened to the end of the column to provide additional support for long pieces. The machine is powered by a 1-hp. reversing motor and will drill and tap holes up to ½ in., National Coarse Thread, in mild steel.

Close Temperature Control Provided by New Thermocouple

A new thermocouple supplied with either No. 8 ga. standard chromel alumel or iron constantan element so that it can be used with any make of pyrometer has been announced by *Arklay S. Richards Co., Inc.*, 64 Winchester St., Newton Highlands 61, Mass.

Close temperature control is obtained by the use of a ⅞-in. O.D. seamless drawn Inconel protecting tube which fits thermocouple element closely for maximum sensitivity of response. This is particularly advantageous on automatic control installations. The protecting tube has a wall thickness of 0.147 in., and is made of 80 nickel, 13% chromium alloy.

The terminal head is designed so that the thermocouple can be inspected without disconnecting leads or using a screw driver. Thermocouples wires also enter connector without bending. The thermocouple element is replaced by loosening two screws. The ceramic connector body withstands high temperatures, thus reducing renewal of this part on severe applications.

These thermocouples can be used for all general heat treating service including neutral salt baths; except sulfurous atmospheres. The standard lengths are from 12 in. to 48 in., inclusive, in multiples of 6 in.; and 60 to 144 in., inclusive, in steps of 12 in.

Ultrasonic Inspection Device Reveals Flaws in Materials

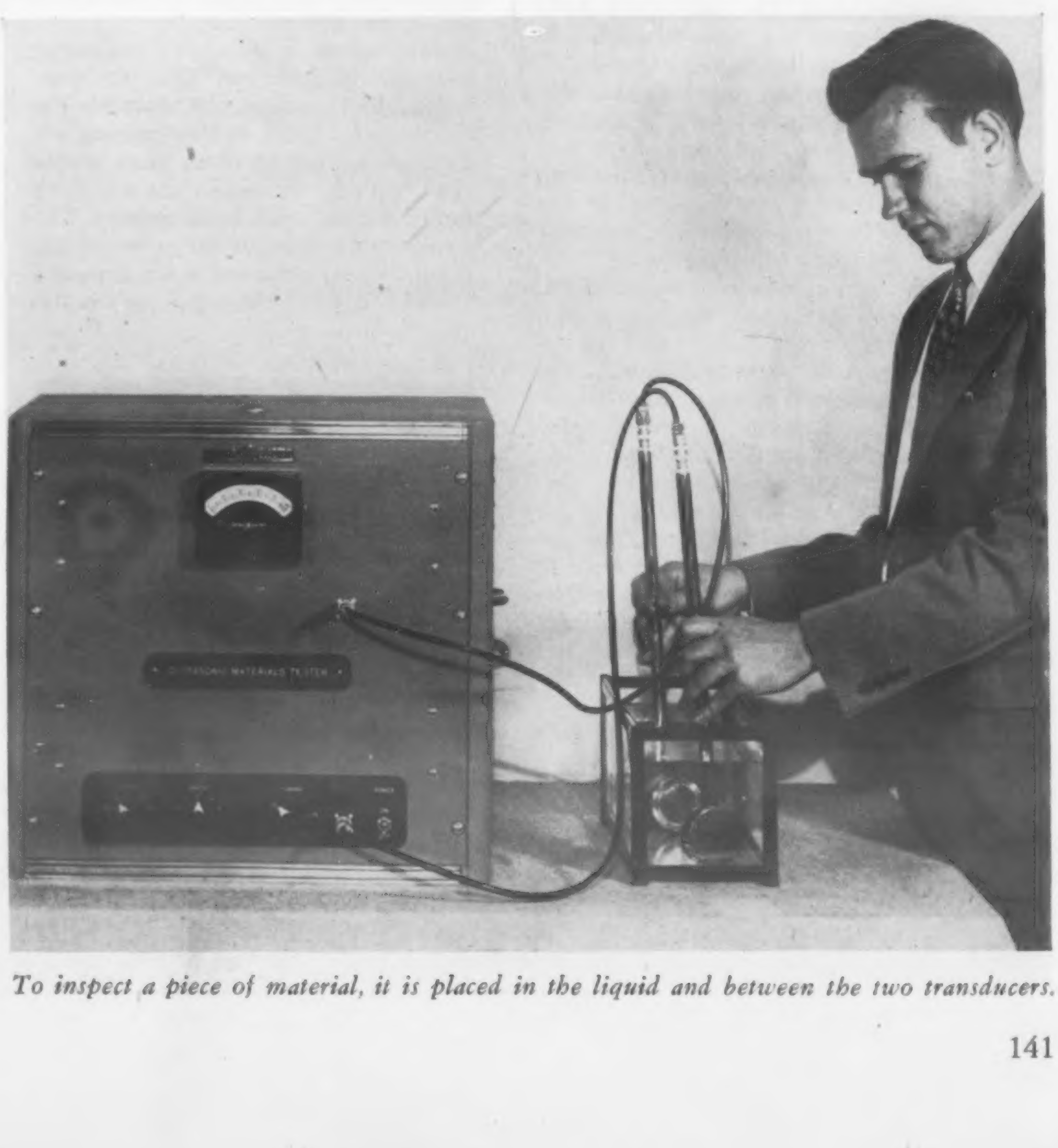
An ultrasonic materials tester designed to indicate the presence of voids, cracks, porosity, laminations, poor bonds, and other internal flaws in metals, plastics and ceramics has been introduced by the *Special Products Div., General Electric Co.*, Schenectady, N. Y. The tester is useful in production testing of metal castings, forgings, or finished machined parts, as well as plastic or ceramic parts.

The tester sends a beam of ultrasonic waves through the specimen being tested. Changes in the amount of energy transmitted through the specimen are an indication of the presence and extent of flaws. The tester is portable and self-contained, and provides a direct reading. Testing is not affected by small changes in dimensions or position of test pieces.

The new instrument consists of a complete wide-band ultrasonic transmitting-receiving system having a high-frequency generator, a crystal transducer for producing ultrasonic vibrations, a satisfactory medium such as water to transmit these vibrations, a second crystal transducer to convert the received mechanical energy into electrical signals, and an indicator supplying information for materials inspection or analysis.

To examine regularly-shaped specimens, the two transducers are immersed in a tank containing water, and the specimen is inserted between them. Ultrasonic waves are then sent through the specimen, and the resulting reading on the indicating instrument is compared with that for a specimen shown to be sound by X-ray, mechanical breakage, or sectioning methods. Internal flaws will produce measurable decreases in total transmission of waves through the specimen, and a consequent drop in the instrument reading.

The instrument can also be used to indicate changes of viscosity, compressibility, and density of liquids, when these significantly alter the velocity or attenuation of ultrasonic transmission.



To inspect a piece of material, it is placed in the liquid and between the two transducers.

Portable Hardness Tester for Rounds and Flats Up to 1 In.

A unique portable hardness tester that handles rounds and flats up to 1 in. and gives direct readings in the Rockwell scales with diamond and ball penetrators has been developed by *Ames Precision Machine Works*, Waltham 54, Mass.

The tester measures depths of penetrations in materials to determine the degree

This portable Rockwell hardness tester weighs less than 2 lb.

of hardness. A diamond point penetrator is used in testing hard materials and a ball point penetrator for testing relatively soft materials. Screw action rather than weights and levers is employed.

Pressure is applied in Kilogram loads to force the penetrators into the material. These pressures also cause the C frame to spring, thereby moving the indicator pointer to graduations on the dial.

The tester weighs less than 2 lb. and is rustless throughout. It comes complete with penetrators, anvils and test blocks.

Electroplating Rectifier Uses Aluminum Back Plates

Development of an electroplating rectifier that employs selenium-on-aluminum cells has been announced by *Wagner Brothers, Inc.*, Dept. "K", 422 Midland Ave., Detroit 3. These cells are said to be able to handle momentary overloads of as much as 1000% of normal capacity. Aluminum back plates in place of steel provide maximum cooling, and low velocity air circulation is provided by three 10-watt, 1.5-amp. fans.

The rectifier has an effective area of over 4300 sq. in. It occupies a floor area of 5½ sq. ft. and is 34 in. high, 36 in. long, 22 in. wide.

Brush-On Enamel Stripper Has Fast Action

A new spot enamel stripper for removal of synthetic enamel and other coatings has been developed by *Enthone, Inc.*, Dept. MA, 442 Elm St., New Haven, Conn. This stripper can be used for stripping of enamel on large parts that cannot be immersed in a stripping solution.

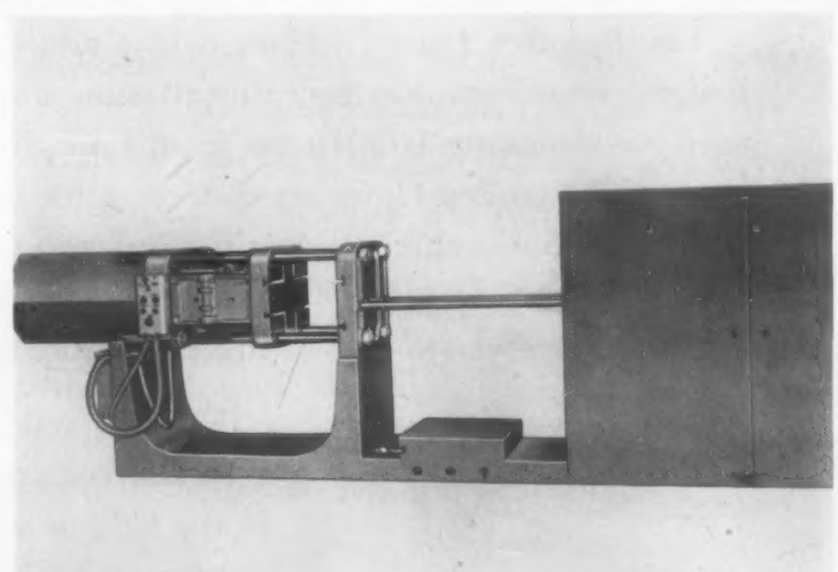
It is a slightly viscous liquid, known as S-45, that can be brushed, sprayed or applied by dipping. It contains a non-waxy evaporating retardent that keeps the stripper on the work until stripping action is completed. Stripping is accomplished by a wrinkling action so that the enamel can be brushed, wiped, or scraped off. No waxy residue is left to interfere with adhesion of subsequently applied finishes.

The stripper is said to have fast action on most synthetic enamels as well as certain nitrocellulose coatings. It is not satisfactory for linseed oil paints, phenol-formaldehyde enamels or vinyl type coatings. Modified urea-formaldehyde, melamine, and alkyd coatings are rapidly stripped. Most enamels are loosened in about 5 min., although some may take longer and require several applications. The stripper has no harmful action on metals, plastic, or wood.

Die Casting Machine Has Maximum Casting Rate of 500 Shots Per Hr.

A new die casting machine of the high-speed cold chamber injection type with center gate for casting aluminum, magnesium and brass alloys is being produced by *H. L. Harvill Manufacturing Co.*, Corona, Calif. Provision is made for conversion to hot chamber operation for casting zinc, lead and tin base alloys. These latter alloys may also be cast as cold chamber die castings, wherein the metal is hand ladled to the shooting cylinder, if so desired.

The machine is basically a small, light weight cold chamber type capable of casting up to 2.6 lb. of aluminum, or a proportionate volume of other base metal alloys, at a maximum reduction rate of 500 "shots", or casting cycles, per hr.



This small, light weight die casting machine is capable of casting up to 2.6 lb. of aluminum.

Engineering specifications provide for normal die dimensions of 13½ in. vertical by 23 in. horizontal with a dimension of 10 in. between dies in the open position and a maximum thickness of the dies when closed of 19 in.

The die platen size is 19 in. by 23 in. overall. Oversize dies may be used if arrangement of the cavity area provides for the longest dimension to be horizontal and the volume of metal does not exceed the specified maximum. The vertical dimension of dies is limited by the position of the bars through the die platens. Clearance between the 1¾-in. tie bars is 13¾ in. vertically by 11¾ in. horizontally.

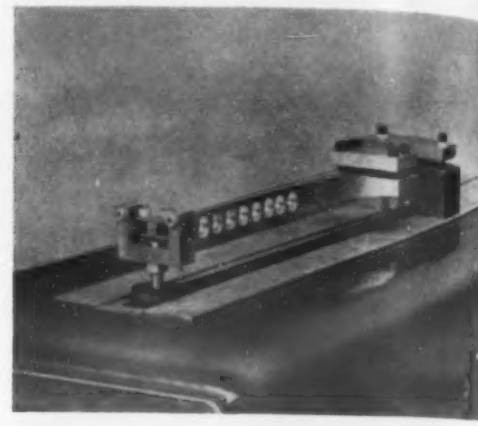
The "shooting" or injection piston has a diameter of 4 in. with a stroke of 13 in. Operating under 1000 psi. oil hydraulic pressure, a pressure of 5000 psi. is applied on the molten metal injected into the die cavity. The overall dimensions are: 2 ft., 8 in. in width by 12 ft. in length by 4 ft., 6 in. in height.

Operation is actuated by oil hydraulics provided by a Vichers pump and driven by 5 hp. electric motor of 220-v., 60 or 50 cycle, 3-phase type. Controls are semi-automatic with automatic time cycle adjustments of die opening and closing. The controls are safety-interlocked so that metal cannot be injected until the dies are locked in their closed position. The hydraulic-mechanical locking device locks the dies under 100-ton pressure.

Bench Fatigue Tester Has "Constant-Force" Loading

To fill the increasing need for a bench-type fatigue testing machine with the "constant-force" loading feature, the *Baldwin Locomotive Works,* Philadelphia 42, offers the Sonntag Model SF-2 machine. The new machine can be used for flexure fatigue tests on sheet stock of metal, plastic and wood. The design eliminates the need for any electronic equipment, complex linkage or special device to maintain a constant force while the specimen is under test.

The testing machine uses a revolving eccentric mass as a means of loading the



The "constant-force" fatigue testing machine with a specimen mounted for testing.

specimen. With this constant force machine, the load automatically remains constant regardless of the changes in the amount of deflection of the specimen. A predetermined load is alternately applied to the specimen, and the resulting deflection is incidental. In dynamic testing with this machine the specimen undergoes the same stresses the material would sustain in actual use and the point of failure is accurately determined.

The machine measures 15 by 12 by 32 in., and can be placed in a cabinet during a test so that temperature and humidity can be controlled. The machine weighs 115 lb., has an alternating force capacity of 20 lb. and a speed of 1800 cycles per min., with a total travel of the loading yoke of 1 in. per cycle.

● A new type of industrial resistance thermometer bulb developed by *Leeds & Northrup Co.,* 4911 Stenton Ave., Philadelphia 44, is good to temperatures as high as 1000 F. This thermometer bulb, known as Thermohm, has a speed of response matched only by small pipe-type or fine wire couples. It has a corrosion-resisting stainless tube for protection at normal pressures and against non-corrosive fluids. The temperature coil is thoroughly protected against contamination by moisture or gases. It is equipped with the standard universal head that facilitates installation and connection.

Improved Resistance Welders Announced

In recent months several welding equipment manufacturers have introduced new improved designs of their standard resistance welders.

An improved line of standard motor driven flash welders, designed for flash welding virtually any metal, including aluminum, for long periods at high production, has been announced by *Progressive Welder Co.*, 3050 E. Outer Drive, Detroit 12.

The machines may be operated on either a.c. through transformers, or d.c. through the use of storage batteries. All units—including electrical and mechanical units—are enclosed within the machine frame, and flat tops on most of the machine types help make these welders more universal in their applications. Machine control is from one position.

Welding speeds in these machines have been materially increased by close coupling of the welding current. This provides increased efficiency and also results in higher welding current for a given flashing voltage. Another feature is the side rail construction of the moving platen which maintains accurate product alignment. There are multistep taps on the transformers permitting 16 distinct steps from 30 to 100% of capacity.

The flash welders are available in four capacities from 20 kva. to 150 kva., or they can be battery operated for welding jobs within the physical capacity of the machine. Upset pressures are 2250, 4500, 11,500 and 19,600 lb. for the four machine sizes; maximum stock width, vertical fixture is 2, 4, 6 and 8 in.; and maximum tube O.D., vertical fixture, is 1, 1¼, 1¾ and 2¼ in.

A new type air operated press welder with roller anti-friction welding head has been developed by the *Taylor-Winfield Corp.*, Warren, Ohio. There are two styles: one is either a projection welder or a

This Taylor-Winfield air operated press welder has a roller anti-friction welding head.

combination projection and spot welder when horns are used (Style 1); the other is a spot welder with a swiveling lower horn (Style 2).

In these welders the top switches are connected to the transformer without flexing the primary leads, and provision is

(*Continued on page 146*)

made for use of side mounted electrical controls. They are of composite copper-steel knee construction for maximum rigidity when projection welding.

The roller anti-friction welding head was developed because of the need for a head mechanism in which the friction would be constant and at a minimum, yet perform satisfactorily with little maintenance over a long period of time.

These welders are built to operate on single phase, a.c., 220, 440 or 550 v., and 50 or 60 cycle. Style 1 welders are available with throat depths of 12, 18, 24 or 30 in.; Style 2 machines have a throat depth of 18, 24, 30 or 36 in.

A new series of rocker arm spot welders designed to handle work in the light to medium range is offered by the *Thomson Electric Welder Co.* of Lynn, Mass. Available either as foot, air or motor operated machines with 12-, 24- or 30-in. throat depth and 20-, 30- or 40-kva. transformer capacity, this series provides a group of machines for shops doing general spot welding and special duty welders for mass production assembly line work.

In addition to the rocker arm action, these welders have the features designed to improve performance and simplify maintenance. These include: patented tubular secondary transformer with non-corroding, non-clogging secondary sections and hard rolled primary windings; fabricated steel frame substantially reinforced to minimize deflections; heavy duty, 8-point positive clamp type heat regulator with star locking wheel; and indexed terminal block on which all wiring of air or motor operated machines is centralized to facilitate maintenance, testing and inspection.

● A d.c. power supply has been designed by the *Superior Electric Co.,* 148 Church St., Bristol, Conn., for continuous duty, small regulation and easily adjusted output voltage. The maximum d.c. output current is 0.5 amp. It operates from a 115-v., single phase, 50/60 cycle source.

Six-Ton Hydraulic Press Offers Speed and Versatility

A 6-ton capacity air hydraulic press for assembly, riveting, embossing, staking, sizing, crimping and flanging on metals and plastics is being produced by *Air-Hydraulics, Inc.,* 410 Broadway, New York 13. This press is offered in both bench and floor models.

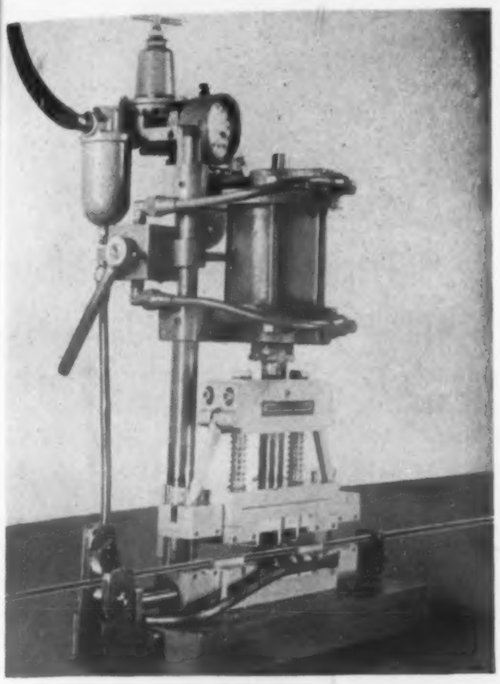
The press may be plugged into the present airline; the 6-ton model works on a 120 to 1 ratio on the air intake pressure. Ram pressure is adjustable and is controlled to predetermined specifications from pressures up to 12,000 lb. The same pressure is delivered throughout the length of the stroke, making possible operations that otherwise require greater power. Ram speed is adjustable from the slowest action to 300 rpm.; the stroke is adjustable from 1/16 to 5 in.

Bench Wire Stripper Operated by Compressed Air

A wire stripping machine, which cuts, strips and slits one, two and three conductor wire up to ½-in. dia., has been announced by the *Williams Products Co.*, Middletown, Conn.

This bench machine can be used by large and small manufacturers for production, semi-production, or custom work. One or all of the three basic operations are performed simultaneously on both ends of the cord.

The stripper, known as Codeco, is operated by compressed air. Sixty pounds air pressure will operate the machine to process most cord. Hardened steel knives are adjusted to cut, strip and slit to the user's specifications.



This versatile wire stripping machine cuts, strips and slits wire.

All stripped material is removed automatically, thus eliminating the possibility of damage to the knives in cleaning. Bronze bearings are used throughout. It measures 18 in. wide, 11 in. deep and 25 in. high.

Sapphire Tips Used on Honing and Burnishing Tools

The development of four new sapphire tipt honing and burnishing tools has been announced by *Sapphire Products Div., Elgin National Watch Co.*, Elgin, Ill. Two of the new tools are designed for fitting into lathe or drill press, and are used with water as a coolant.

Three advantages are claimed for sapphire tipt tools: The burnishing tool holds to size and remains strictly accurate; it does not mark or score the bearing; because sapphire is a nonmetallic and completely nonporous, it does not seize on or tear any portion of the bearing surface and does

(Continued on page 148)

not close the pores of pre-lubricated powdered metal bearings.

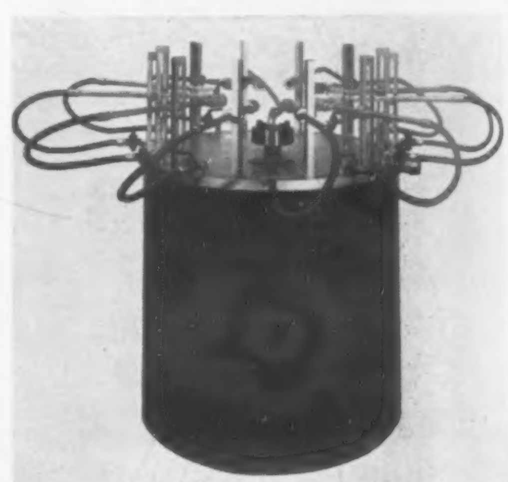
One of the burnishing tools is designed to apply very high finishes to outside surfaces and counterbores; the other is for sizing bearings. They are one-end tools and usually are fitted into a lathe. The two tools are made in diameters from 0.200 to 0.700 in.

Two sapphire tipt hand burnishing tools which feature double ends are included in the current development. One of them has solid sapphire members protruding, and a round aluminum barrel with hexagon caps to protect the ends. It is used chiefly for small parts burnishing and honing. The other is a flat double end honing and burnishing tool with solid sapphire inserts of two different grits. It is used for larger or heavier work than the round barrel job, accomplishing efficiently the chores of longer-established diamond and carborundum tools.

Flame Heat Treater for Development and Production Jobs

A small flame heating unit designed for experimental and development work as well as for a variety of small scale production jobs is now being manufactured by *Gas Appliance Service, Inc.*, 1211 Webster Avenue, Chicago 14. It consists of a circular arrangement of burners directed towards the center of the unit where the work piece is placed. There are 12 burner arms and several different types of burners. The number and type of burners used can be varied to fit each particular job.

In the development stage of heat treating operations this midget heat treater makes it possible to determine how a job can be



This midget heat treater has 12 burner locations that can be adapted to the requirements of each application.

done, how much heat and time is required before the operation is put on a production scale. Besides this use, it is also suitable for all types of flame hardening, brazing, soldering or annealing operations where production requirements do not necessitate a large unit.

The overall dimensions of the unit are:

(Continued on page 149)

height, 42 in.; height to table top, 30½ in.; diameter, 30 in. It will burn any manufactured, mixed or natural gas. The gas consumption is from 10,000 to 500,000 Btu. per hr., depending on the number of burners used.

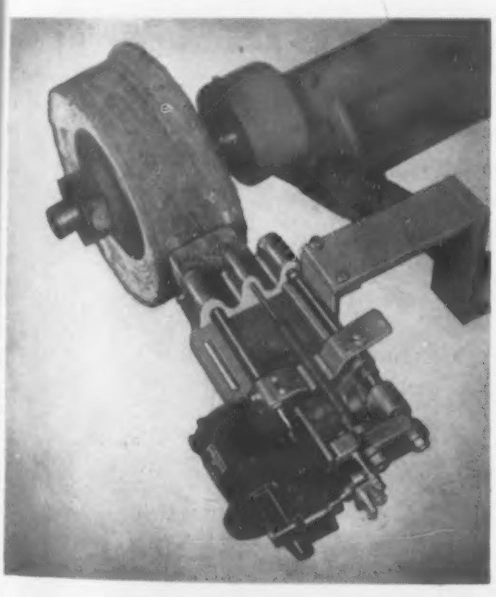
The unit can also be furnished with a quench tank and air cylinder for lowering work into the quench and raising it above the burner ring.

● A machine for hot pressing all types of nonferrous metal and alloy powders has been announced by the *National Diamond Hone & Wheel Co.*, 108 Fulton St., New York. The press is especially adapted to the production of corrosion-resistant metal of high density.

Buffing Compound Applicator Adaptable to All Automatic Machines

A new buffing compound applicator that has an intermittent feed control operating at the rate of 14 strokes per min., and a feed ranging from 0.0015 in. to 0.015 in. per stroke has been announced by the *George L. Nankervis Co.*, 5442 Second Blvd., Detroit 2. The applicator can be mounted on any automatic machine (either right or left-hand), and can be adapted to everything from the simple to complex multiple-stage buffing operations.

The device is driven by an enclosed geared head motor. The compound applicator clamp, with adjustable features to compensate for variable thicknesses and standard carrier, will accommodate any



A typical installation of the buffing compound applicator showing relation of applicator to buffing wheel.

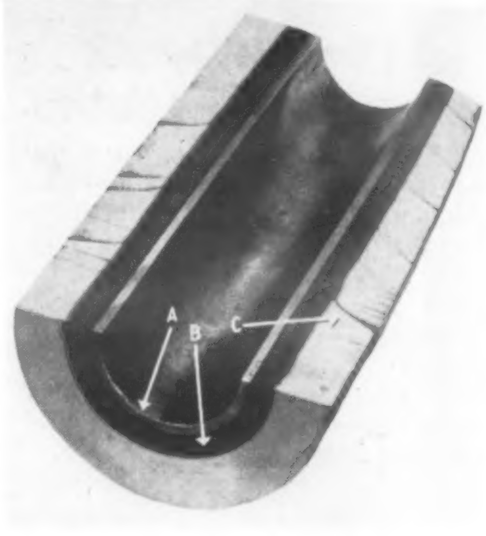
length stick of compound up to 4 in. Special carriers for wider cakes are available. Total weight is 20 lb.

This automatic method of applying the compound as compared to feeding by hand is said to save compound, improve the quality and uniformity of the work, and speed up the job.

Life of Pickling Line Rolls Increased in New Design

Almost complete resistance to damage from cuts is claimed for a new hold-down roll for steel-mill pickling lines developed by *Goodyear Tire & Rubber Co.*, Akron, Ohio. This roll utilizes an inner cover of fibrous material which guards the steel core from contact with acid. The new roll continues to utilize a high grade synthetic rubber cover on the weight-carrying surface. This outer cover is unaffected by acids.

Until development of the new fibrous material, cuts in the rubber surfaces of pickling tank rolls often permitted acid to reach the core and destroy it. This fibrous material absorbs the shock of practically all cuts to which pickling tank rolls are subjected, while remaining immune itself to damage from acid seeping through the gash. The roll's synthetic rubber surface is bonded in turn to the fibrous material with a newly-developed bonding process.



Cross-sectional closeup of new hold-down roll. A—Steel core of roll; B—fibrous inner cover which armors core against acid penetration; C—test cuts inflicted on outer rubber surface failed to pierce secondary fibrous cover.

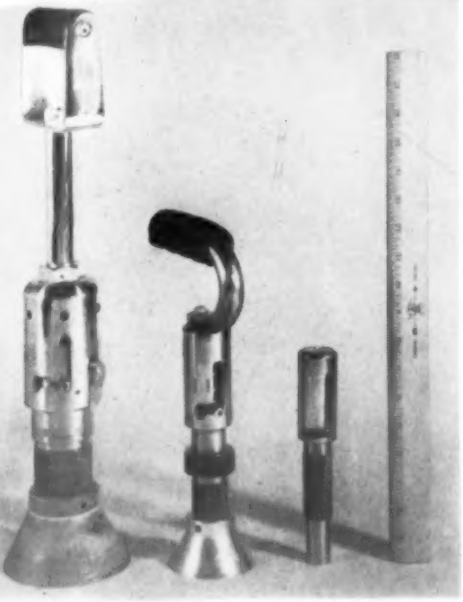
In the pickling process, these rolls are used to carry sheet steel through baths of sulfuric or other acids to remove scales from the steel before further rolling. Regardless of the diameter of the rolls, the protective fibrous material is applied to the core in a ¼-in. layer. Similarly, the rubber weight-carrying surfaces of the rolls will remain about ¾ in.

● An adjustable multiple spindle drilling attachment that drills eight holes at one time has been announced by the *Commander Manufacturing Co.*, 4225 W. Kinzie St., Chicago 24. It can be attached to any drill press to drill eight holes at one stroke in any hole pattern on or within a 9-in. circle. Minimum center distance is ½ in. The positioning of the spindles to any hole pattern is accomplished by loosening one nut on each of the eight locating arms, positioning the spindle, and tightening the nut.

Explosive Powered Hand Tool Performs Fastening Jobs

A new hand tool for fastening jobs using the explosive power principle of operation has been introduced by the *Tempo Products Co.*, 402 Perry-Payne Bldg., Cleveland 13. The principal uses of this tool are to punch holes in steel, and to attach steel to steel or steel to concrete, brick or mortar.

The source of power for the tool is provided by exploding a blank cartridge in an enclosed chamber or breach. In this respect, it is similar in its operation to a firearm. The explosion drives a pin or stud through the short barrel and into steel with such force that the stud is "set" firmly in the steel. Tests show that in some cases the set stud will resist a direct pull up to 20,000 lb. This, of course, varies with the model tool used, the power cartridge employed and the hardness of the steel. In addition to the drive pins, which are used mainly for fastening purposes, both male and female threaded studs are available to accommodate bolts or threaded rods. Thus, large objects can be fastened directly to the seated stud.



Three models of the new explosive power tool are available.

There are three models: the "22" for attaching metal objects up to 1/8-in. thick to steel or concrete; the "38", which can be used with mild steel up to 5/8-in. in thickness; the "45" for use on heavier jobs requiring penetration of mild steel up to 1 1/4-in. thick. Cartridge charges of three different powers are available for the "38" and the "45".

● A low temperature rub-on solder for aluminum work is being marketed by *All-State Welding Alloys Co.*, 96 W. Post Rd., White Plains, N. Y. It can be used on the assembly of aluminum shapes and wire in production work. On aluminum castings, this alloy has good matching color and fair corrosion resistance. It is suitable for filling and soldering where tightness is essential but strength is unimportant.

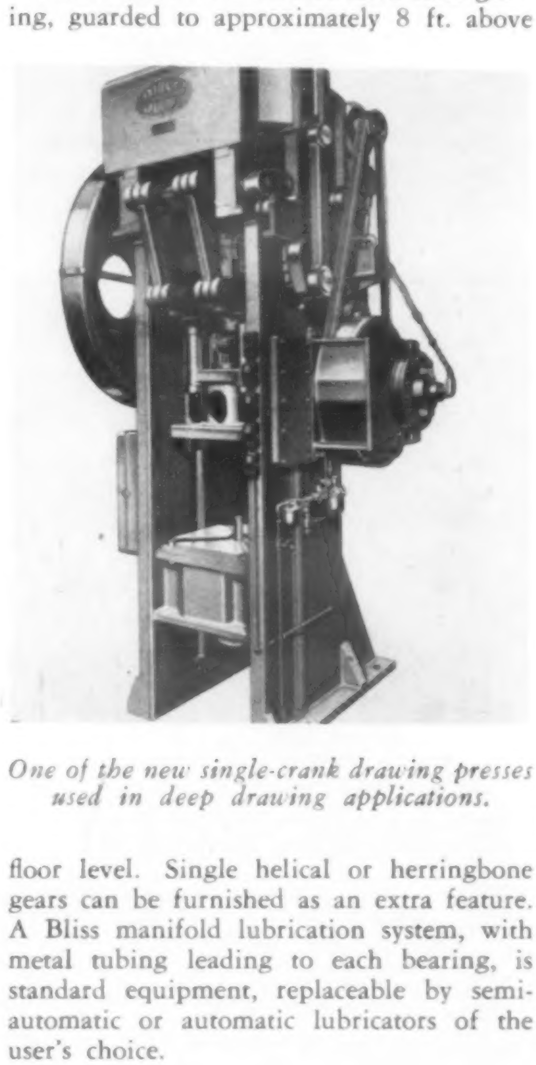
Single-Crank Toggle Presses Designed for Deep Drawing

A new line of single-crank toggle presses in eight sizes ranging from 4¼- to 7-in. shaft dia. and from 8½- to 24½-in. stroke length, has been announced by the *E. W. Bliss Co.*, 450 Amsterdam Ave., Detroit. They are used for deep drawing operations on steel, brass, copper, aluminum and other metals.

The new designs are of steel-weldment construction. Operating speeds, stroke lengths and die-space dimensions remain the same as those for previous models, thereby permitting interchange of tools. Redesign of the toggle driving mechanism provides a cross head with long guides at the position where it is most needed. Steel rockshafts, yokes and links are provided in the toggle-driven blankholder mechanism.

The presses feature as standard equipment radially T-slotted bolster plates, and direct-connected adjustable bottom lifts out to leave the space between the uprights free and clear.

All of the new machines have steel gearing, guarded to approximately 8 ft. above



One of the new single-crank drawing presses used in deep drawing applications.

floor level. Single helical or herringbone gears can be furnished as an extra feature. A Bliss manifold lubrication system, with metal tubing leading to each bearing, is standard equipment, replaceable by semi-automatic or automatic lubricators of the user's choice.

● A new line of zirconium refractory base combustion tubes, used in carbon and sulfur analysis, is offered by the *Harry W. Dietert Co.*, 9330 Roselawn Ave., Detroit 4. These new tubes incorporate design and materials to give tubes which will withstand high temperatures, withstand thermal shock and resist metal splatter. The tubes are gas tight and have long life at high temperatures up to 2800 F.

News of...

ENGINEERS COMPANIES SOCIETIES

Engineers

John A. Comstock has been made engineer of materials at the Ithaca, N. Y. plant of the Morse Chain Co. He was formerly manager, metallurgical laboratory, Westinghouse, at East Pittsburgh. He will head Morse's newly formed department of materials engineering and metallurgy. Mr. Comstock will set up production material standards and control and have charge of the chemical and metallurgical laboratory.

Theodore P. Nordin, Jr. graduate of Massachusetts Institute of Technology, has joined Battelle Memorial Institute, where he will do research on the engineering properties of materials. He was a structure engineer with the Douglas Aircraft Co.

Henry C. Boynton has resigned as consulting metallurgist, John A. Roebling's Sons Co., and will do consulting work in the manufacture of wire and wire products, with headquarters at 935 Carteret Ave., Trenton 8, N. J. He has done some writing for the technical press, including MATERIALS & METHODS, and may continue writing.

C. W. Culbertson has become metallurgical engineer for McNally Pittsburg Foundries, Inc., Pittsburg, Kans. He will be in charge of advisory technical service to castings buyers in the western half of the country.

Charles S. Hegel has become manager, Stainless Steel Div., Joseph T. Ryerson & Son, Inc., having been metallurgist, Crucible Steel Co. *John W. Queen* has been made manager of the Alloy Steel Div., having been heretofore manager of Ryerson's Alloy Steel Department at New York. He has served as chairman of the New Jersey chapter, American Society for Metals, and of the by-laws committee of the National ASM.

John F. Black has been made general superintendent, Buffalo plant, Wickwire Spencer Steel Div., Colorado Fuel & Iron Corp. Other associations have been with Atlas Steels, Ltd., Welland,

News of...

ENGINEERS COMPANIES SOCIETIES

Ont., and Bethlehem Steel Corp. at Sparrows Point, Md.

M. E. Crist has become executive vice president and general manager, Nitralloy Corp., having been affiliated with engineering, inspection and production for many years. He is a graduate of the U. S. Naval Academy and Postgraduate School and of Massachusetts Institute of Technology.

E. C. Kron, formerly with Battelle Memorial Institute, is now with the Doehler-Jarvis Corp., as metallurgist in charge of steel and iron activities, with headquarters at Toledo, Ohio.

H. J. French has been made assistant vice president, International Nickel Co. of Canada, Ltd., having been assistant manager, Development & Research Div. He is a past president of the American Society for Metals, and is prominent with several other technical societies. He has done important executive war work for the government, is an author and technical society medal winner.

Howard W. Dunbar retired as vice president and general manager, Norton Co., as of Jan. 21. He is rated as a leader in the machine tool world, and in this capacity served with the War Production Board. He is the author of many technical articles and books, and has sponsored new methods in the grinding and machine tool fields. He was president of the National Machine Tool Builders' Assn. in 1938. He will continue with Norton as consultant.

William R. Balph has been made works metallurgist, Cuyahoga Works, Cleveland, American Steel & Wire Co., having been Cold Roll Div. metallurgist since May, 1944, where he is succeeded by *Stuart J. Kelley. William R. Miller* becomes assistant manager, metallurgical department, wire company, while *John F. Occasione* has been made division metallurgist in charge of process control. *Merle H. Seifert* has become division metallurgist in fine wire.

Edward A. Ledeen, formerly chief engineer, Gotham Engineering Co., has become general manager of Production Methods, Inc., New York. He has been chief tool engineer for Brewster Aeronautical Corp. and project tool engineer on the B-17 and TBY-2 programs.

William H. Lenz has resigned as chief metallurgist after nine years with Fansteel Metallurgical Corp., being retained by Fansteel as consultant for the

News of...

ENGINEERS
COMPANIES
SOCIETIES

rest of the year. Recently he has done consulting work for Permo, Inc., Chicago, and is now serving them full time as metallurgical director.

Dr. Lawrence C. Hicks has been made assistant director of research, Allegheny Ludlum Steel Corp., having been associate director of research in charge of magnetic steel and allied products. He belongs to three prominent metal technical societies. Other appointments in research involve *John H. Crede, Claude M. Sheridan* and *William J. Baldwin.*

Otto W. Winter has been made president and manager, Acme Pattern & Machine Co., Inc., Buffalo. He is a former president of the American Society of Tool Engineers and is also president, Idea Development Corp., an engineering and designing firm supplementing Acme's engineering staff.

Harry E. Orr has become general manager of operations, Bridgeville, Pa. and Niagara Falls plants, Vanadium Corp. of America.

Maurice J. Hoke has become chief engineer, Crankshaft and Camshaft Divs., Ohio Crankshaft Co., Cleveland.

Companies

The *Reynolds Metals Co.* has inaugurated a new service by establishing the "Technical Advisor", a monthly technical paper devoted to how to use aluminum mill products most effectively. The current series is devoted to the welding of aluminum.

The *Lapointe Machine Tool Co.*, Hudson, Mass., world's oldest and largest maker of broaches and broaching machines, recently completed a colored sound film, "Surface Broaching."

United Chromium, Ltd., has been formed in Canada at 15 Emily St., Toronto, as a subsidiary of the United States company of approximately the same name. It will be in charge of James Guffie.

Donald M. MacMillan, formerly with Eclipse-Pioneer Div., Bendix Aviation Corp., has formed his own company at 7 Warren St., Bergenfield, N. J., to engage in electronics research and development, industrial design and technical service. Facilities include an electronics laboratory and an experimental machine shop.

News of...

ENGINEERS COMPANIES SOCIETIES

Bertold Wolff Ore & Chemical Corp., 80 Broad St., New York 4, has set up a special service involving the solving of individual assorting and separating problems. He will deal with identifying metals, assorting out contaminations and picking valuable material from a mixture of various metals, etc.

The *Cleveland Chain & Mfg. Co.*, Cleveland, has purchased the *Woodhouse Chain Works*, Trenton, N. J.

The general sales offices of both the *DoAll Co.* and the *DoAll International Co.* have moved their entire facilities into new streamlined quarters at 254 N. Laurel Ave., Des Plaines, Ill.

The *Oliver Iron Mining Co.* has planned a long range program of research, construction and expansion in iron ore beneficiation involving $34,000,000 in the next six years. An important phase will be studying the practicability of using low grade ores.

The *National Twist Drill & Tool Co.* has removed all manufacturing facilities to its new Rochester, Mich. plant.

All research activities of the *Babcock & Wilcox Co.* will eventually be conducted in a building on a 20-acre site near Alliance, Ohio, purchased from the *Buffalo Weaving & Belting Co.*

The *Ladish Drop Forge Co.*, Cudahy, Wis., has changed its corporate name to *Ladish Co.*, since the scope of its manufacture has broadened beyond its original name.

International Nickel Co., Inc., is broadening its cooperation with universities and colleges. It will furnish each institution 50 specimens of nickel-containing materials; a portable metals identification kit with 35 specimens of important metals for qualitative identification; literature and other data on nickel and motion pictures.

The *Lodge & Shipley Co.*, Cincinnati, has acquired the turret lathe and hand screw machine business of the *Acme Machine Tool Co.*, same city. The purchase did not include the capital stock of Acme, but merely patents, good will, patterns, trademarks, jigs, fixtures, inventory and associated items.

The *Linde Air Products Co.* announces plans for construction of a new oxygen-filling station and acetylene producing plant at Jackson, Miss.

News of...

ENGINEERS COMPANIES SOCIETIES

The *Monsanto Chemical Co.* has formed a new manufacturing division at Texas City, Tex., using as nucleus a 50,000-ton styrene plant bought from the War Assets Administration for $9,550,000.

Leeds & Northrup Co., maker of electrical instruments and heat treating furnaces, has been given the first annual Industrial Relations award of the Philadelphia Chamber of Commerce and Board of Trade.

A continuous slab heating furnace to heat steel alloy billets prior to rolling will be built for *Allegheny Ludlum Steel Corp.* at Brackenridge, Pa., by the *Rust Furnace Co.,* Pittsburgh.

Societies

The *Engineering Foundation,* through its chairman, Dr. A. B. Kinzel, 29 W. 39th St., New York, announces that in view of the postwar increase in opportunities for productive research in engineering, the Foundation would welcome bequests and gifts to supplement its current principal fund of about $1,000,000.

A feature of the recent annual banquet of the *Masters' Electro-Plating Assn., Inc.,* was the presentation of a model of a plating barrel to Joseph F. Brust in recognition of "his loyal and tireless service to the electroplating industry." The model was made entirely of brass and plated all over with a heavy coating of gold.

Under the auspices of the *American Electroplaters' Society* an Industrial Finishing Exposition will be held in Convention Hall, Detroit, from June 23 to 27, inclusive. It will provide the first postwar opportunity to see developments of the past few years. Many exhibits will be in actual operation.

The third annual spring meeting of the *Metal Powder Assn.* will be held at the Waldorf-Astoria Hotel, New York, May 27. There will be morning and afternoon technical sessions.

The National Plastics Exposition, sponsored by the *Society of the Plastics Industry, Inc.,* will be held May 6 to 10 at the Coliseum in Chicago. It will dramatize through new product exhibits, new machinery developments and new fabricating techniques the prog-

News of...
ENGINEERS
COMPANIES
SOCIETIES

ress and potentials of plastics to the nations' industries. More than 150 exhibitors already have been assigned space.

The *National Association of Metal Finishers, Inc.*, was recently incorporated, with offices at 2236 Dime Bldg., Detroit. Raymond M. Shock is executive secretary. The first annual meeting of the association is scheduled to be held at the Hotel Statler, Detroit, June 22-25.

Preston M. Hall, outstanding figure in the resistance welding industry, has accepted the position of technical executive of the *Resistance Welder Manufacturers Assn.*, with headquarters at 505 Arch St., Philadelphia 6. The association will award $2000 in cash prizes in 1947 for outstanding papers dealing with resistance welding subjects, the contest closing July 31, 1947.

Meetings and Expositions

American Gas Association, industrial and commercial gas conference. Boston, Mass. March 17-19, 1947.

American Institute of Mining & Metallurgical Engineers, world conference on mineral resources. New York, N. Y. March 17-19, 1947.

American Society of Lubrication Engineers, annual meeting, Pittsburgh, Pa. March 17-19, 1947.

American Society of Tool Engineers, annual convention. Houston, Texas. March 19-22, 1947.

American Society for Metals, Western metal congress and exposition. San Francisco, Calif. March 22-27, 1947.

Safety Convention and Exposition, annual meeting. New York, N. Y. March 25-28, 1947.

Midwest Power Conference, Chicago, Ill. March 31-April 2, 1947.

National Association of Corrosion Engineers, annual meeting. Chicago, Ill. April 7-10, 1947.

Electrochemical Society, spring meeting. Louisville, Ky. April 9-12, 1947.

Southern Machinery & Metals Exposition. Atlanta, Ga. April 14-17, 1947.

American Foundrymen's Association, national convention. Detroit, Mich. April 29-May 2, 1947.

BOOK REVIEWS

Steelmaking Discussed Informally

TALKS ABOUT STEELMAKING. *By Harry Brearley. Published by American Society for Metals, Cleveland, Ohio, 1946. Cloth, 6¼ x 9¼ in., 236 pages. Price $3.50.*

This highly interesting and unique book on steel is written by an internationally known English chemist and metallurgist. He was the discoverer or inventor of stainless cutlery steel.

The book is largely non-technical—really "talks" on various steel topics and of interest to a wide variety of readers. It is "part suggestion, part history, part criticism and essentially a biased point of view." The various chapters can be read in any sequence—one does not depend on another. They are like a conversational discussion on various topics. There has been no effort to make a continuous story.

The various chapters—13 in all—are as follows: I—Beginnings (chemical analysis and microscopes), II—Molten Steel, III—Melting Processes (Huntsman, Bessemer, Siemens, Thomas, electric), IV—Forging, V—Testing Steel, VI—Notch Fractures, VII—Making Specifications (chemical composition, mechanical properties), VIII—Clean Steel, IX—The Job's the Boss, X—Complaints, XI—Remunerations, XII—Helpful Comparisons, and XIII—"Scrapalurgy."

As the author says: "This book has been written—active occupations growing less—from a comfortable seat in a sunny window with neither opportunity nor inclination to collect data and look up references." This reflects the tone of the entire book—one of cordiality and informality.

Practical Cupola Operation

HANDBOOK OF CUPOLA OPERATION—FIRST EDITION. *Published by American Foundrymen's Assn., Chicago, 1946.* Cloth, 6¼ x 9¼ in., 470 pages. Price $4.50 to members; $5.50 to non-members.

This is a welcome addition to the Handbooks of the country. It is of decided value to cupola foremen, foundrymen in many classifications, and to metallurgists. It is also a splendid example of cooperative editorial effort.

The book is a product of the Cupola

Research Project or committee of the A.F.A. This committee was organized a few years ago to consider the advisability of research work in the cupola. An executive committee of about 35 leading foundrymen was appointed, followed later by subcommittees on Equipment; Ferrous Materials and Alloys; Pig Iron; Scrap Alloys, Slags, Fluxes and Desulfurizers; Fuels and Combustion; Operation and Process; Refractories; and Finance. Each one of these contains from 10 to 40 members, all experts in each field.

There are 24 chapters and 3 appendices. Each subcommittee was made responsible for most of the chapters. For example, the subcommittee on Operation and Process was responsible for the chapters on Cupola Operation, Melting Nonferrous Metals in the Cupola, and Appendix I on Applications of Cast Iron. The subcommittee on Equipment was responsible for the chapters on Cupola Design, Tuyeres, Special Cupolas, Mechanical Charging Equipment, Blowing Equipment, Blast Control Equipment, Equipment for Measuring the Temperature of Molten Iron, Cupola Slag Disposal, and so on. The subcommittee on Slags, Fluxes and Desulfurizers was responsible for the chapters on Cupola Slags; Fluxes and Fluxing; and Alkali Desulfurizers and Desulfurizing. Other chapters were handled in a similar manner. The chapters are a product of the combined experience of the experts on the various subcommittees. Over 100 practical cupola operators and foundry metallurgists compiled the extensive data.

It is an intensely practical book, written by foundrymen for foundrymen. It contains 188 illustrations, 35 tables and a valuable bibliography of nearly 500 references.

Revised Data on Finishing

FINISHING METAL PRODUCTS—SECOND EDITION. *By Herbert R. Simonds & Adolph Bregman. Published by McGraw-Hill Book Co., Inc., New York, 1946. Price $4.00.* The first edition of this book, brought out in 1935, was written by Mr. Simonds. This, the second edition, has as co-author Mr. Bregman, also an authority in this field.

In the preface to this new edition, the authors say that before the war the importance of protection and appearance in finishing metals had been well established. The war, however, disturbed certain established trends and values—more emphasis was placed on protection and less on appearance, operations were speeded up, and less attention was paid to costs. With more normal conditions in sight, the factors of appearance and cost are becoming more prominent. Coatings with new and surprising properties have appeared as the result of the rapid progress in plastics and synthetic resins.

The many developments which took place during the war and in the years just preceding are discussed in this new edition. The entire subject, as covered in the first edition, is brought up-to-date in this

volume and considerable new material is added. Important additions are chapters on coloring metals, on costs and estimates, and on organic coatings.

The book offers a broad discussion of the finishing of metal products, particularly the more attractive metal finishes and the more efficient means of producing them. Other subjects covered include the technique involved, commercial aspects, sales value of attractive finishes, the economics and equipment, the design of parts, and metal finishing costs.

Other New Books

LABORATORY MANUAL IN METALLOGRAPHY. *By J. F. Eckel and R. J. Raudebaugh. Published by McGraw-Hill Book Co., Inc., New York, 1946. Paper, 8¼ x 10¼ in., 344 pages. Price $4.50.* This manual contains 42 experiments from a series of three metallography courses given at Purdue University over a period of six years.

REYNOLDS ALUMINUM ALLOYS AND MILL PRODUCTS DATA BOOK. *Published by Reynolds Metals Co., Inc., Louisville 1, Kentucky, 1946. Cardboard, 6¼ x 8¼ in., 245 pages. Price $2.00.* Describes the aluminum alloys and mill products of the Reynolds company, with technical data on characteristics and treatment.

ARSENAL OF DEMOCRACY. *By Donald M. Nelson. Published by Harcourt, Brace & Co., New York, 1946. Cloth, 6 x 8¾ in., 439 pages. Price $4.00.* A clear and impressive picture of the American war production program, and of the men who shaped it to final victory—Roosevelt, Wilson, Batt, Gen. Somervell and many others, written from a unique personal vantage point.

SPECIFICATIONS AND TESTS FOR ELECTRODEPOSITED METALLIC COATINGS. *Published by American Society for Testing Materials, Philadelphia, Pa., 1946. Paper, 6 x 9 in., 46 pages. Price $1.25.* This is a compilation of standard specifications and tests for electrodeposited metallic coatings, issued under the joint sponsorship of the A.S.T.M. and the American Electroplaters' Society.

POTENTIAL HAZARDS IN MOLTEN SALT BATHS FOR HEAT TREATMENT OF METALS. *Published by The National Board of Fire Underwriters, New York, 1946. Heavy paper, 6 x 9 in., 40 pages. Free to members of the N.B.F.U. and to the industry.* Workable requirements and regulations safeguarding salt bath heat-treating baths are suggested. A bibliography is included.

QUALITATIVE ANALYSIS BY SPOT TESTS—THIRD EDITION. *By Fritz Feigl, translated from the German by R. E. Oesper. Published by Elsevier Publishing Co., Inc., New York, 1946. Cloth, 6¼ x 9¼ in., 574 pages. Price $8.00.* The old "spot test" standby with several new features, including a bibliography on the application of spot reactions for special scientific and technical purposes. 125 references.

METCO METALLIZING HANDBOOK—FOURTH EDITION. *Published by Metallizing Engineering Co., Inc., Long Island City, N. Y., 1946. Cardboard, 6 x 8½ in., 86 pages. Price $2.00.* The most complete collection of up-to-date technical and operating data covering the metallizing process is claimed to be found in this handbook. The preparation of surfaces, the metallizing technique and the finishing procedure are discussed in complete detail. Besides this there are chapters containing complete information on corrosion resistance, specific gravity, hardness, bond strength, tensile strength, and relative shrink. There is also a profuse supply of photographs, drawings, charts and so on. It is of decided practical value to anyone interested in this field.

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The Last WORD

by T. C. DU MOND

Aluminum for Snaths

Recently we read in one of Alcoa's publications that their favorite material is now about to replace wood in snaths. The snath makers, of which there are about five in the United States, estimate that 1947 will see a production of approximately 120,000 snaths. Here is another example of the newer light metals replacing some of the old-time favorites.

Dogs Wagged by Their Tails

This department is still too young to have had any opportunity of testing its strength, but if we go through the same stages as some metals we may someday find that this is the tail (should we say tale) that wags the big dog to which it is appended. The strange phenomena to which we refer is the situation in which metal producers find themselves. A recent rise in steel scrap prices made scrap more expensive than pig iron. The same situation held with copper and some of the other relatively scarce nonferrous metals.

Roomy Roomettes

The connection between this item and our field of interest may be only dimly discernable, but we can't help but comment. The Budd Co. now announces that they have designed a "cabin" type sleeping car in which the "Thin Man" and his brother detective the "Fat Man" will be equally comfortable. The latter character will certainly appreciate the fact that he can lower his berth without protruding halfway across the car's corridor.

Watch Out Below

Apparently there aren't enough natural and synthetic hazards now which we have to dodge in an often futile attempt to keep limbs and head intact. Now come a group of physicists who are toying with the production of man-made meteors produced by shooting particles of metal into the air at a velocity so great that they are heated to incandescence by friction. Just what practical value there is in meteors remains to be seen, but in the meantime let's hope such experiments are confined to the V-bomb areas of New Mexico.

Applause from the Audience

Not having seen any statistics on the matter, we can't say which takes the most effort—the hissing and booing of disapproval or the polite signalling of satisfaction. We rather suspect that the former is the easier, for it seems human to voice a complaint much more readily than to pay a compliment. For this reason we are especially appreciative of those individuals who take the time to write saying how well they like a particular article or issue. Sometime, however, we would like to hear from a reader or readers telling how some of the technical information presented helped in the solution of some annoying problem. We're not asking for applause—directly—but if we are able to learn what has helped you, we can give you more of the same in the future. In other words, feed the kitty if you want an encore.

An Editor's Social Life

Rumblings in the distance indicate that editors of technical journals will soon enter a previewing period that promises to surpass any of the past years. Publicity men seem to have reached the conclusion that editors can better understand and appreciate new products or new offices if they are viewed through a highball glass or from across a heaped dinner plate. It's not that we're complaining, you understand, but we would just like to have the reader know that keeping up-to-date with progress is not all beer and skittles. The rumblings referred to could be either one of two things—the opening of a battery of bourbon bottles or the warming of vocal chords of waiting wives.

The Show(s) Must Go On

You who feel it necessary to attend the trade and technical shows pertaining to the metalworking industries had better hire a helper to assist you. If one really tried he could probably find enough shows and meetings to keep him busy steadily from now through Thanksgiving. It's our guess that one of the best attended shows this year will be that of the Machine Tool Builders, who will unveil the results of their development departments for the first time in about seven or eight years. This year's show is to be held in Chicago in September and will be housed in the gigantic Dodge plant. The show is scheduled to last 10 days and that probably won't be long enough for many people.

Little Hope in Taxes

On one of our recent sojourns in Washington to listen to the bigwigs talk to business paper editors, we got the distinct impression that, despite all optimistic public statements on tax reductions, high taxes are here to stay for a long, long time. It's too bad that a governmental unit can't pull in its horns and economize to operate within its income the same as individuals and private enterprises must do to survive.

What's A Snath?

To save you the trouble of searching for the answer to "What is a snath?," we will report the answer we found in a hurried trip to our much used dictionary. A snath is the long bent handle of a scythe. We'll bet that most farmers using scythes don't know that the wooden handles (soon to be aluminum) they wield so competently have such a fancy name.

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